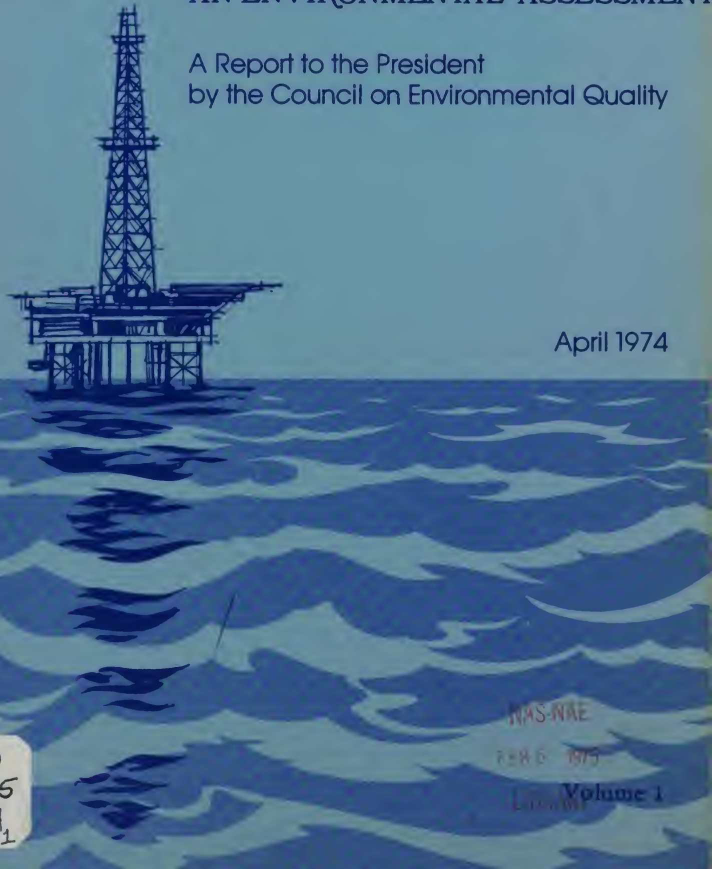
OCS OIL AND GAS —
AN ENVIRONMENTAL ASSESSMENT

A Report to the President
by the Council on Environmental Quality



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EXECUTIVE OFFICE OF THE PRESIDENT
COUNCIL ON ENVIRONMENTAL QUALITY
72 JACKSON PLACE, N. W.
WASHINGTON, D. C. 20006

April 18, 1974

Dear Mr. President:

In your Energy Message of April 18, 1973, you announced your decision to defer any drilling on the Atlantic Outer Continental Shelf and in the Gulf of Alaska until a study of the environmental impact of oil and gas production in these areas could be carried out. You asked the Council on Environmental Quality to make this study in consultation with the Environmental Protection Agency, the National Academy of Sciences, other Federal agencies, and the Governors, legislators, and citizens of the coastal states involved. The attached report, *OCS Oil and Gas–An Environmental Assessment*, presents our findings.

In carrying out your directive, we have reviewed environmental impacts in broad terms. The study focuses on a number of hypothetical drilling sites in areas considered by geologists to be particularly promising for oil and gas discovery. We have analyzed the potential impact on the marine environment of developing these sites, as well as the likely onshore impacts of industrialization and growth related to processing oil and gas. The report includes chapters assessing the technology of oil and gas production and the institutional and legal mechanisms for managing OCS development.

The Council concluded that leasing and development undertaken in the Atlantic OCS or in the Gulf of Alaska should be guided by a set of essential principles stipulated in Chapter I of our report. By following these principles and a number of specific recommendations, the Council believes that environmental risks can be minimized. We stand ready to work with the appropriate Federal agencies in implementing these recommendations.

The philosophy underlying our report is that the benefits of potential oil development must be balanced against the risks of environmental damage. When this balance is favorable, development should proceed with caution and with a commitment to minimize damage. When the balance is unfavorable, the Council believes that development should not move ahead until environmental risks can be lowered to an acceptable level.

The Council's study found that the risk of environmental damage varies from area to area. Development of the Georges Bank and the Southern and Central Baltimore Canyon would involve relatively lower environmental risk than development in the Northern Baltimore Canyon, the Southeast Georgia Embayment, and the Gulf of Alaska–all higher risk areas.

The offshore oil and gas industry has made substantial progress in technology and work practices since the 1969 Santa Barbara blowout. In addition, more stringent Federal regulations for OCS operations have been issued, and enforcement of these regulations has been strengthened. Over 17,000 wells have now been drilled in waters off the United States coast. However, our study has found that operations in both frontier OCS regions would confront harsher conditions than have been previously faced in other United States offshore areas and that conditions in the Gulf of Alaska are more severe than the industry has yet experienced anywhere in the world.

Potentially discoverable economically recoverable oil has been estimated from United States Geological Survey data to be 10 to 20 billion barrels in the Atlantic OCS and 3 to 6 billion barrels in the Gulf of Alaska. The figures for gas are 55 to 110 trillion cubic feet in the Atlantic and 15 to 30 trillion cubic feet in the Gulf of Alaska. Last year, from all sources, the United States consumed about 7 billion barrels of oil and about 24 trillion cubic feet of gas.

A decision to move ahead with oil and gas development on the Atlantic OCS and in the Gulf of Alaska will call for close coordination of planning among Federal, state, and local governments. The creation of strong and expert coastal zone management agencies in the states involved and thorough implementation of the National Environmental Policy Act will help to insure that the interests of the State governments and their citizens will be appropriately represented.

In conducting this study, the Council held public hearings in Washington, D.C., Alaska, and various cities on the Atlantic coast. Representatives of environmental groups and of industry were consulted and kept advised of the study's progress. An advisory committee representing the Governor of each Atlantic coast state and Alaska was established and on three occasions met with the Council to review progress. Much of the research and information contained in the report was developed through contracts with universities and private consulting firms working with the Council and a number of Federal interagency working groups. Finally, a special panel of the National Academy of Sciences (NAS) performed a critique of our study which is attached to this report.

The NAS panel's critique generally endorses the findings and recommendations of CEQ's report. Specifically, the panel commends the report as a useful first step toward the development of new Federal policies for resource development in these two OCS areas. The panel also concurs with the Council's recommendations for decreasing the risk of OCS operations and for minimizing onshore impacts through improved coordination among governmental agencies.

The panel agreed with the assessment that OCS operations in the Gulf of Alaska would present the highest environmental risk but took exception to the Council's ranking of regions in the Atlantic OCS. The panel expressed the belief that the criteria used in making the rankings were inadequate and incomplete and that other criteria should be considered. The Council believes that consideration of the other criteria mentioned by the NAS panel would not have changed the relative order of ranking. In fact, the effect of oil on the offshore marine environment was considered to the extent possible, as were the alternative uses of the OCS.

Other issues raised by the NAS critique, such as an expanded involvement of the Federal Government in oil and gas exploration, the relationship of this study to Project Independence, and national policy on annual energy growth rates, are clearly outside the scope of the assignment covered by this study. The Council will continue, of course, to work with the Department of the Interior, the Federal Energy Office, and other Federal agencies on the role of OCS oil and gas resources and other factors in our national energy policy.

We hope that our report satisfactorily provides the study of environmental impact you requested to help assess the future course of action on the OCS.

Respectfully,

Russell W. Peterson

Russell W. Peterson, Chairman

John Busterud

John A. Busterud, Member

Beatrice E. Willard

Beatrice E. Willard, Member

The President
The White House
Washington, D.C. 20500

Preface

On April 18, 1973, the President asked the Council on Environmental Quality to work with the Environmental Protection Agency, in consultation with the National Academy of Sciences and other Federal agencies, to study the environmental impact of oil and gas production on the Atlantic outer continental shelf and in the Gulf of Alaska. The President also specified that Governors, legislators, and citizens of these areas should be consulted.

This report summarizes information and analyses provided to the Council by many sources over the year of study.

Federal interagency working groups were formed to develop the scope of work and to monitor the progress of the study. Federal agency representatives who contributed to the study are listed in Appendix A. Contracts were awarded to consultants and universities to study specific subject areas (they are listed in Appendix B). A Governors' Advisory Committee, consisting of one designee from each Atlantic coast state and from Alaska, served in a consultative and review capacity (see Appendix C for members' names).

In accord with the President's request, the National Academy of Sciences independently analyzed the Council report. The Academy's critique is attached.

The Council involved the public directly in this study. In September and October of 1973, the Council held public hearings and briefings to gather information from citizens, environmental groups, industry, and government officials. Hearings were held in Washington, D.C.; Boston, Mass.; Mineola, Long Island, N.Y.; Philadelphia, Pa.; Ocean City, Md.; Jacksonville, Fla.; and Anchorage, Alaska. A summary of these hearings may be found in Volume II.

The Council gratefully acknowledges the efforts of Federal agencies, state and local governments, contractors, industry representatives, and members of environmental and public interest organizations who have contributed to this report. Special thanks go to the members of the Governors' Advisory Committee and the National Academy of Sciences review committee who generously contributed their advice and time.

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Chapter 1. Summary of Findings and Recommendations

This is a report about energy development and the environment. It was prepared by the Council on Environmental Quality in response to the President's April 18, 1973, request to "study the environmental impact of oil and gas production on the Atlantic Outer Continental Shelf and in the Gulf of Alaska." [1]

This report, and the studies that contribute to it, take on great importance in view of the pressures of the energy crisis and the drive toward self-sufficiency. In his January 23, 1974, Energy Message, for example, the President directed the Secretary of the Interior to triple leasing originally planned on the OCS to 10 million acres in 1975. However, recognizing the complex environmental issues involved, he reiterated his commitment that leasing on the Atlantic OCS and in the Gulf of Alaska would not go forward pending the results of this study.

This report presents the results. It squarely faces the issues of energy development and environmental protection. And it concludes that these objectives are not mutually exclusive. It does not give the drillers a green light. Nor does it call for a freeze on development. Instead, it assesses the relative environmental vulnerabilities of the areas studied and recommends procedures, requirements, and stipulations for protection and for development. The recommendations attempt to provide environmental guidance on alternative OCS development decisions.

The report establishes an agenda for action to improve OCS technology, tighten regulation and enforcement of OCS operations, and untangle the bewildering web of institutional interests between the states and the Federal Government and among the Federal agencies. It provides information and methods of analysis that should be useful to the Department of the Interior and other Federal agencies in considering environmental aspects when determining those sites to hold back from lease sale and those to offer for lease and in integrating environmental factors into the design of an optimum leasing schedule. The data and methodology provided here will also help states and localities to anticipate and plan for the onshore impacts of OCS development. And, of course, it will aid in preparing environmental impact statements for individual lease sales.

SCOPE OF THE STUDY

This study assesses the potential environmental impacts of oil and gas development on the Atlantic and Gulf of Alaska outer continental shelves:

- *Chapter 2, Oil and Gas Resources*, examines estimates of potential oil and gas resources in the Atlantic and Gulf of Alaska.
- *Chapter 3, Perspectives on Energy Growth*, projects potential energy needs and evaluates the environmental impacts of fuels that can be used to meet these needs.
- *Chapter 4, Technology for Developing Oil and Gas Resources Offshore*, reviews the basic steps of offshore oil and gas exploration and presents estimates of oil spill probabilities.
- *Chapter 5, Natural Phenomena and OCS Development*, explores the unusual physical conditions facing operations in the Atlantic and in Alaska.
- *Chapter 6, Offshore Effects of OCS Development*, concentrates on the environmental impact of operations in the ocean, on the shelf, and along the coast resulting from the exploration, production, and transportation of oil and gas.
- *Chapter 7, Onshore Effects of OCS Development*, analyzes the economic, social, and environmental impacts of onshore development—oil

refining, gas processing, petrochemical manufacturing, and support services–induced by development offshore.

- *Chapter 8, Technology and Environmental Protection*, examines the extent to which oil and gas exploration and production technology and practices protect the environment.
- *Chapter 9, Institutional and Legal Mechanisms for Managing OCS Development*, looks into the effectiveness of Federal regulatory and enforcement processes and the broader issues of government coordination and planning.

Witnesses at the Council's public hearings on OCS development suggested many areas of study oriented toward modifying the current OCS management system. Proposals ranged from fundamentally changing the roles of government and industry in developing resources on public lands to alternative methods of bidding on OCS leases. They included suggestions to set up a public corporation for oil and gas exploration and development in new OCS areas, to authorize the U.S. Geological Survey or a public corporation to conduct all exploratory drilling, to adopt a new leasing system based on royalty bidding rather than on bonus bidding, and to establish an exploration leasing system which would precede issuance of development leases.

While these and other such proposals merit consideration within the context of an evolving national energy policy, they involve extremely complex technical and financial issues not directly related to the environmental impacts of OCS oil and gas operations and thus do not fall within the scope of this study. For similar reasons, this report does not include economic analyses of alternative OCS management arrangements or of alternative energy supplies.

BACKGROUND

The Outer Continental Shelf Lands Act of 1953 [2] is the basic charter governing exploration for the development of the minerals and other resources under the OCS. In essence, it is a statute designed to promote development, enacted well before the major environmental legislation of the past few years· the National Environmental Policy Act of 1969 (NEPA) [3] and three 1972 laws–the Coastal Zone Management Act, [4] the Federal Water Pollution Control Act Amendments, [5] and the Marine Protection, Research and Sanctuaries Act. [6] This new legislation has in effect "amended" the OCS Lands Act by requiring incorporation of more stringent environmental values and needs in its administration.

Oil and gas development on the Gulf of Mexico and California OCS began with exploration in shallow state waters nearshore. The first offshore platform was constructed in 1897 off Santa Barbara. Fifty years later, the first platform out of sight of land began operating off Louisiana. Today's multibillion dollar offshore oil industry was well established before the Federal Government began selling leases on the Gulf of Mexico OCS nearly 20 years ago. Since then the industry has grown dramatically, advancing into deeper waters. Until recently Federal supervision was primarily concerned with volume of resources produced and operation of leases; from 1954 to 1968, over 7,300 wells were started on the OCS. In 1969, however, the blowout of a Union Oil Company platform in the Santa Barbara Channel focused national attention on the hazards of offshore operations. Subsequent accidents accompanied by fires in the Gulf of Mexico underscored questions about the adequacy of OCS technology and practices.

Since then, more stringent Federal regulations for OCS operations have been issued and the Federal enforcement effort has been strengthened. However, environmental groups and individual citizens continue to express concern, not only about massive oil spills and fires, but also about discharges of oily water, drilling mud, and drill cuttings–the "housekeeping" operations of an offshore facility–and about the changes that result on land from industrial and other development generated to support offshore drilling operations. As CEQ heard time and again at the public hearings, particularly along the Atlantic, the public is concerned about the overall impact of offshore oil production on the oceans, beaches, and wetlands and on the shoreside communities where the oil is landed and processed or which serve as bases for servicing offshore operations.

STATEMENT OF PRINCIPLES

Whether to open specific frontier areas in the Atlantic and Gulf of Alaska OCS is a critical public policy issue because of the importance of these resources to our Nation's energy needs, the possible risk of damage to the environment, and the potential impact on the economy and social structure of communities onshore resulting from construction of refineries and other support facilities. Such an issue must be approached with caution, intelligence, and judgment.

On the basis of its yearlong study, the Council on Environmental Quality has concluded that leasing undertaken in these waters must be conducted under carefully stipulated and controlled conditions, and that the Federal Government must be guided by and committed to the following principles in choosing areas to lease and in administering environmentally safe offshore operations:

- Exploration and development of the OCS must take place under a policy which puts very high priority on environmental protection.
- The location and phasing of OCS leasing should be designed to achieve the energy supply objectives of the leasing program at minimum environmental risk.
- The best commercially available technology must be used to minimize environmental risks in new OCS areas.
- Regulatory authorities available to Federal agencies must be fully implemented and requirements strictly enforced to minimize environmental risks in new OCS areas.
- Planning at all phases of OCS oil and gas operations must respect the dynamic relationship between initial Federal leasing decisions and subsequent state and local community action. The states and the communities affected must be given complete information as early as possible so that planning can precede and channel the inevitable development pressures. Experience must be continuously integrated into the management process.
- The interested public must be given the opportunity to participate and play a major advisory role in the Federal management and regulation of the OCS.

These principles, if applied consistently by responsible government and industry decisionmakers at all stages of the development of new OCS areas for oil and gas, will provide the basis for policies and programs that can significantly reduce risk to every element of the environment.

Development of OCS oil and gas in accordance with these principles poses major challenges to Federal management and regulatory agencies, to the states affected by the offshore activities, and to the oil industry. Risk of damage to the human and natural environment is an inseparable part of almost any development, including the OCS. The guiding principles must be to keep risks at an acceptable level and to balance risks with benefits. Only when the risk is acceptable should we proceed—and then only with caution and with a commitment to prevent or minimize damage. This means that the oil industry must have adequate technology and must use it safely, that Federal agencies must exercise their management and regulatory responsibilities to ensure that the oil industry meets its obligations, and that Federal, state, and local agencies must coordinate their efforts to minimize disruption of coastal communities and environments by those facilities and other development required to support offshore operations.

MAJOR FINDINGS AND RECOMMENDATIONS

This section presents the major findings and recommendations of the Council study.

Relative Ranking of Environmental Risk of OCS Areas

In the April 18, 1973, Energy Message announcing this study, the President said that "[no] drilling will be undertaken . . . until its environmental impact is determined." Thus the major questions that the Council attempts to answer here are: What are the relative risks of development in these OCS areas? What can be done to reduce these risks? In what ways is our knowledge too little to answer these questions?

To provide a framework for answering these questions, CEQ identified 23 hypothetical locations of potential oil and gas accumulations in the Atlantic OCS and in the Gulf of Alaska and 8 sample onshore areas where the induced industrial development from oil and gas production could occur. For the Atlantic, four resource locations were identified in the Georges Bank Trough off New England, five locations in the Baltimore Canyon Trough off the Middle Atlantic, and five locations in the Southeast Georgia Embayment off the coast from northern Florida to South Carolina. The sample onshore sites studied were Bristol County, Mass.; Cumberland/Cape May Counties, N.J.; Charleston, S.C.; and Jacksonville, Fla. (see Figure 1-1). For the Gulf of Alaska, nine resource locations were identified, and potential onshore effects were examined at Cordova and Valdez and in the Puget Sound and San Francisco Bay areas (see Figure 1-2).

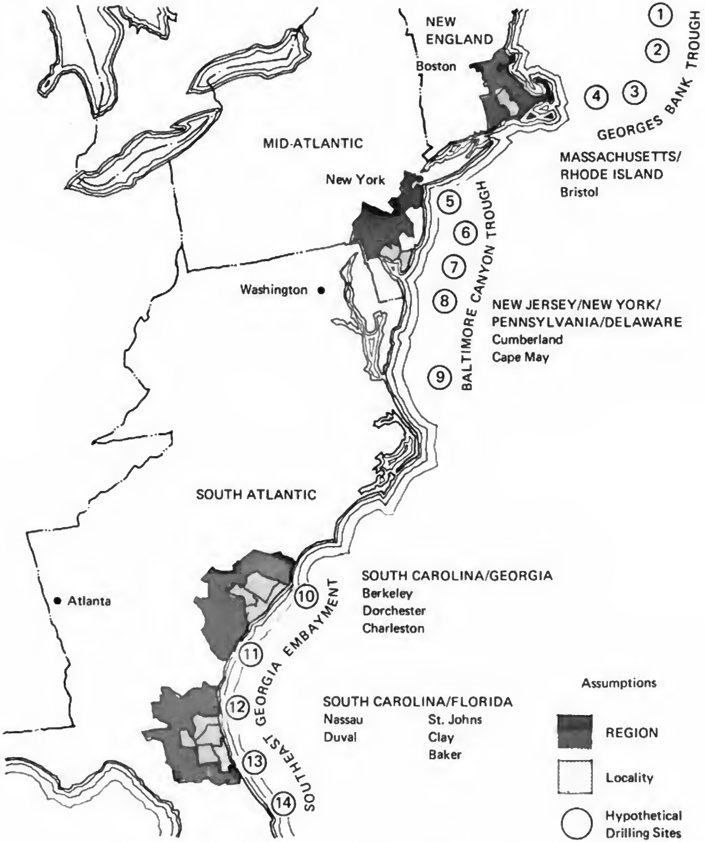

Figure 1-1. Atlantic Hypothetical Drilling Sites and Hypothetical Onshore Development Areas

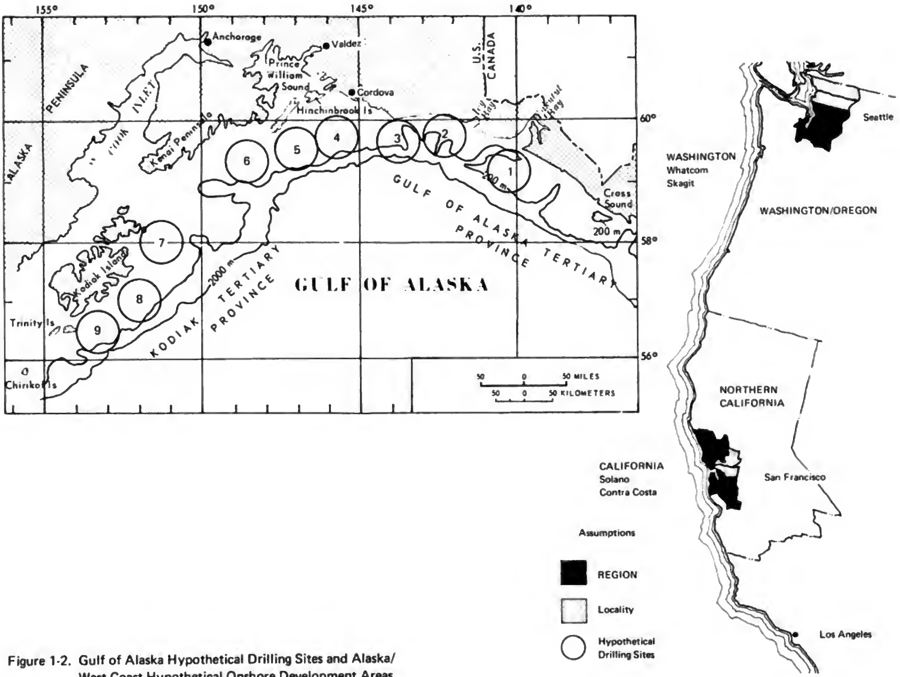

Figure 1-2. Gulf of Alaska Hypothetical Drilling Sites and Alaska/ West Coast Hypothetical Onshore Development Areas

Chapter 2 discusses in detail the methodology for selecting these hypothetical resource locations, and Chapter 7 deals with the sample onshore site selections.

The Council believes that the following order of relative environmental risk applies to development of the Atlantic and Alaskan outer continental shelves:

Lowest Risk

- Eastern Georges Bank (East of 68° W; EDS 1 and 2)
- Southern Baltimore Canyon (South of 37° N; EDS 9)
- Western Georges Bank (West of 68° W; EDS 3 and 4)
- Central Baltimore Canyon (between 37° and 39.5° N; EDS 6, 7, and 8)
- Northern Baltimore Canyon (North of 39.5° N; EDS 5)
- Southeast Georgia Embayment (EDS 10, 11, 12, 13, and 14)
- Western Gulf of Alaska (West of 150° W; ADS 7, 8, and 9)
- Eastern Gulf of Alaska (East of 150° W; ADS 1, 2, 3, 4, 5, and 6).

Highest Risk

This ranking represents CEQ's best estimate of the overall relative degree of risk to the marine, coastal, and human environment resulting from OCS oil and gas development. Of course, the risk must be balanced against the value and benefits of the oil and gas to be recovered. The ranking is based on an assessment and integration of the findings of this study with respect to the effects of development onshore as well as of oil spills offshore, the incidence of unusual phenomena in potential development areas, the state of technology, and projections of regional energy needs.

CEQ believes that high environmental risk is involved in the development of the Northern Baltimore Canyon, the Southeast Georgia Embayment, and the Gulf of Alaska. Less risk would face development of the Central and Southern Baltimore Canyon and Georges Bank. The risk of damage from offshore operations can be decreased by strict requirements for environmentally protective technology and improved practices. The timing, magnitude, and location of onshore development must be controlled by state and local land use plans and regulations.

Studies of oil spill probabilities show that the size range of individual spills is extremely large, from a fraction of a barrel to over 150,000 barrels, although most spills are at the low end of the range. For example, three spills each year accounted for two-thirds of all the oil spilled from 1970 and 1972. Amounts can vary by a factor of 1 million, and a single large spill distorts the statistical distribution of spill magnitudes. For an oil field find of medium size (2 billion barrels in place), there is about a 70 percent chance that at least one platform spill over 1,000 barrels will occur during the life of the field; for a small oil field find (500 million barrels in place), the chance is about 25 percent. If a large platform spill does occur, there is an 80 percent chance that it will exceed 2,380 barrels and a 35 percent chance that it will exceed 23,800 barrels.

It should be noted that in view of the lack of scientific data on the effects of oil spills and discharges on offshore fisheries, the Council's ranking of offshore damages relies heavily on the probability of oil spills impacting biologically productive coastal wetlands and estuaries and intensively used recreational beaches. This does not mean that oil spills do not cause damage enroute to shore or at sea. It simply reflects the fact that we know something about the effects of oil on wetlands and beaches but considerably less about its effect on the offshore marine environment. Indeed, for many Atlantic areas and particularly for Gulf of Alaska areas, there is a scarcity of information on which to base projections of the impacts of oil on most marine life.

Carefully designed baseline environmental studies should be initiated immediately in potential leasing areas and should be an essential and continuing part of OCS management. Such studies should be closely monitored and coordinated so that information can be integrated into ongoing operations and the results applied to decisions on leasing and regulating new areas. Special attention should be focused on determining long-term or synergistic effects of oil and other pollutants, if any, on marine organisms so that corrective actions can be taken as soon as possible.

Georges Bank. In the Georges Bank, the thick section of sediments with the greater likelihood of oil and gas accumulation lies farther from shore than in any of the other OCS areas considered. Should oil spills occur, the probabilities of oil reaching shore from hypothetical drilling sites located in the eastern part of the Bank (EDS 1 and 2) are generally low–a maximum of 15 to 20 percent in the spring and near zero in the winter (see Table 1-1). The average time required for the oil to reach shore from these sites ranges from 80 to 150 days, with oil from the more remote site (EDS 1) taking the longest time. This is important because oil that has been exposed to long periods at sea, i.e., that is weathered, is less toxic than freshly spilled oil. Even if such oil should come ashore, it is less likely to damage organisms severely in the biologically fragile nearshore and estuarine areas.

In the western part of the Bank (EDS 3 and 4), where the probability of a spring oil spill or discharge reaching shore is 35 to 50 percent and the average time to shore ranges from 40 to 120 days, the physical persistence of oil on the rocky shores of New England would, in general, be less damaging than in the salt marshes and wetlands of the Middle and South Atlantic.

Little is known about the potential biological impacts of oil spills and discharges to fisheries on the Bank itself. These fisheries, however, are valuable and must be protected by stringent controls on discharges.

Analysis of the onshore effects of OCS development in the Georges Bank indicates that there would be significant net economic benefits to New England. Heavily dependent on oil and natural gas, New England could possibly obtain 30 percent of its crude oil and 70 percent of its natural gas requirements from the Bank by 1985, assuming medium energy demand growth and average Georges Bank production estimates.

TABLE 1-1

Probabilities of Oil Spills Coming Ashore from Hypothetical Drilling Sites

Hypothetical spill site	Percent ashore worst season	Percent ashore best season
Atlantic Coast		
EDS 1	15	Near 0
EDS 2	20	Near 0
EDS 3	35	Near 0
EDS 4	50	5-10
EDS 5	10	Near 0
EDS 6	20	0-5
EDS 7	20	5
EDS 8	20	0-5
EDS 9	Near 0	Near 0
EDS 10	95	Near 0
EDS 11	95-100	5
EDS 12	90	15
EDS 13	50	Near 0
Gulf of Alaska		
ADS 1	95	40
ADS 2	95-100	75
ADS 3	95-100	55
ADS 4	95-100	55
ADS 5	95	60
ADS 6	95-100	60
ADS 7	45	5
ADS 8	5	0-5
ADS 9	5-10	Near 0

Source: Massachusetts Institute of Technology, "Oil Spill Trajectory Studies for Atlantic Coast and Gulf of Alaska," *Primary, Physical Impacts of Offshore Petroleum Developments,* prepared for the Council on Environmental Quality under contract No. EQC330 (Cambridge: Massachusetts Institute of Technology, 1974), Report No. MITSG 74-20.

The Council believes that economic activity induced onshore by offshore oil and gas operations would not unmanageably burden the socioeconomic structure or the natural environment. Locally, up to 19,000 new jobs could be created by 1985 (see Table 1–2); regionally, employment could increase 1 to 3 percent and economic output, largely from refining, could increase 1 to 5 percent. Local impacts on land use and social and physical systems due to refinery siting could be severe, although regional impacts would be slight. Adverse impacts could be lessened by directing onshore development activities toward the older cities, like Fall River and New Bedford which need economic stimulants, and away from smaller towns whose social and physical structure could be overwhelmed by large-scale development. Increases in both air and water pollutants can be expected in local areas, even assuming best available control technology, and care must be taken that ambient standards are not violated. The time required for oil to come ashore from these central sites is from 2 to 3 months on the average, with minimum times in the range of 46 days. There appears to be little seasonal dependence in the time to shore, although the probability of impacting ashore is strongly season dependent.

Baltimore Canyon. In the Baltimore Canyon, the thickest sections of sediments parallel the coast 50 to 75 miles out. Should oil spills occur, the probability of their reaching shore from hypothetical drilling sites in the central part of the region (EDS 6 to 8) is generally small, although slightly higher than from EDS 1 and 2 in the Georges Bank. The maximum probability for EDS 6 to 8 is 20 to 25 percent in the spring; during the winter the probability is 0 to 5 percent.

At the northern end of the Baltimore Canyon, the movement of oil spills from hypothetical drilling sites is markedly different. Although there is only a 10 percent chance that oil spilled 50 miles south of Long Island (EDS 5) would come ashore on Long Island during the spring, this probability increases dramatically as the hypothetical oil release point moves north toward Long Island. Oil released 25 miles south of Long Island in the spring would come ashore 75

TABLE 1-2

Summary of Onshore Impacts, East Coast: High Development[1]

Key impacts	New England				Mid-Atlantic			
	1985		2000		1985		2000	
	Local	Region	Local	Region	Local	Region	Local	Region
Primary impacts								
Number of offshore platforms (25,000 barrels per day)	38	38	68	68	38	38	68	68
Number of refinery equivalents (200,000 barrels per day)	1.4	2.8	2.8	5.6	1.9	4.2	2.8	7.2
Number of gas processing plants (500 million cubic feet per day)	2	2	4	8	2	2	4	8
Number of petrochemical complex equivalents (1 billion pounds per year olefins)	0	0.5	0.8	2.4	1.0	2.2	1.9	6.0
Value of incremental construction (millions of 1970 dollars)	196	387	79	155	118	332	7	84
Aggregate impacts								
Employment (thousands)	19.0 (9)	76.7 (3)	17.3 (7)	83.1 (3)	28.8 (19-30)	100.2 (2)	31.9 (20-29)	120.8 (2)
Population (thousands)	43.6 (9)	188.8 (3)	38.8 (7)	191.7 (3)	59.6 (19-27)	227.0 (2)	66.0 (19-26)	268.6 (2)
Acreage required (thousands)	7.0 (8-9)	24.3 (3)	8.0 (9)	26.9 (3)	32.4 (18-26)	49.3 (4)	35.5 (18-25)	57.0 (4)
Hydrocarbon loadings (thousand tons per year)	16.6 (592)	36.6 (6-8)	34.6 (1116)	71.9 (87-134)	27.3 (41-273)	57.3 (7-14)	40.2 (41-338)	103.6 (11-27)
Biological oxygen demand (million tons per year)	0.9 (14)	3.2 (5)	1.8 (23)	5.7 (6)	1.6 (29-88)	4.3 (4)	2.4 (30-104)	7.8 (6)

See footnote at end of table.

TABLE 1-2—*Continued*

Summary of Onshore Impacts, East Coast: High Development[1]

Key impacts	South Atlantic/Charleston				South Atlantic/Jacksonville			
	1985		2000		1985		2000	
	Local	Region	Local	Region	Local	Region	Local	Region
Primary impacts								
Number of offshore platforms (25,000 barrels per day)	38	38	68	68	38	38	68	68
Number of refinery equivalents (200,000 barrels per day)	1.4	2.8	2.8	5.6	1.4	1.4	2.8	4.2
Number of gas processing plants (500 million cubic feet per day)	2	2	4	8	2	2	4	8
Number of petrochemical complex equivalents (1 billion pounds per year olefins)	1.2	2.4	4.2	7.4	0	0	4.2	5.8
Value of incremental construction (millions of 1970 dollars)	228	405	91	162	271	434	108	174
Aggregate impacts								
Employment (thousands)	59.2 (29-41)	87.9 (19-24)	75.8 (28-38)	109.9 (20-25)	37.0 (9-10)	53.9 (11-12)	58.7 (12-13)	84.6 (14-16)
Population (thousands)	137.5 (27-34)	250.8 (20-25)	145.4 (24-31)	272.9 (20-25)	82.3 (9)	142.8 (12-13)	111.2 (10)	202.4 (15-16)
Acreage required (thousands)	26.0 (24-29)	64.6 (16-18)	29.6 (23-29)	75.4 (17-20)	25.4 (7-8)	43.2 (9-10)	33.3 (8-9)	64.9 (11-14)
Hydrocarbon loadings (thousand tons per year	24.5 (75-150)	48.4 (44-111)	47.6 (11-24)	94.9 (62-175)	17.6 (73-149)	21.2 (43-64)	43.2 (111-294)	71.8 (73-156)
Biological oxygen demand (million tons per year)	2.1 (53-78)	5.6 (28-44)	4.3 (81-120)	10.8 (37-60)	2.8 (13-15)	3.8 (15-17)	8.1 (25-31)	11.7 (28-38)

[1] All imports are over base case conditions. The numbers in parentheses represent percentages over base case conditions, the first over Base Case 2 and the second over Base Case 1; where there is only one number, the percentage increase is the same for either base case. See Chapter 7 for a detailed description of cases and impacts.

Source: Resource Planning Associates, Inc., and David M. Dornbusch & Co., 1974, "Potential Onshore Effects of Oil and Gas Production on the Atlantic and Gulf of Alaska Outer Continental Shelf," prepared for the Council on Environmental Quality under contract No. EQ4AC002.

percent of the time; oil released 10 miles south would come ashore 95 to 100 percent of the time during that season. The probabilities are considerably lower in winter.

The potential sites in the Baltimore Canyon are near coastal wetlands and salt marshes which are biologically valuable and serve as prime nesting and feeding areas for waterfowl. Oil reaching these salt marshes would persist in marsh biota and fine sediments for a number of years. In addition, oil spills in the northern part of Baltimore Canyon would tend to beach in northern New Jersey and Long Island, impacting some of the Nation's most intensively used recreational areas.

The northern part of the Middle Atlantic region is one of the most densely populated and industrialized areas in the country. This region contains nearly all of the 1.6 million barrels per day refining capacity now located on the east coast. Because of the larger population and existing industrial base, the regional economic benefits from OCS oil and gas development would be less significant than in New England. Potential oil and gas production from the Baltimore Canyon would provide about 10 percent of regional oil and natural gas requirements by 1985 (assuming medium demand and average production). This production would represent an important contribution to the region's energy needs but would not substantially offset the expanded need for supplemental energy supplies in the region.

As in New England, economic activity induced by OCS development would not appear to cause unacceptable socioeconomic or environmental pressures provided that development is directed to appropriate locations, is adequately planned well in advance, and is controlled. Adverse impacts would be more significant in the southern part of the region, less so in already industrialized areas, but minor in the region as a whole.

If production from the Baltimore Canyon is low, then the oil is likely to be transported by tanker and processed in existing or expanded refineries in the industrial belt between Wilmington and New York City. Although local environmental impacts may result from refinery expansion, the onshore impacts of low Baltimore Canyon production would be little noticed either positively or negatively. However, if oil production is high, it is likely that new refinery capacity would be required and much of the oil piped to new refineries which are likely to be sited in relatively rural areas in the southern part of the region, such as Cumberland and Cape May Counties in New Jersey. By 1985, up to 30,000 new jobs could be created, increasing local employment 30 percent. Local economic output could increase 56 percent, but only 3 to 4 percent in the region. The associated population growth could place great stress on public facilities such as schools, hospitals, and water supplies in the local area. Induced industrial development might cause significant pressures on available unused land.

The southern part of the region could also experience major socioeconomic impacts. Resort industries, agriculture, and light manufacturing are the primary sources of employment now. OCS development could significantly transform the economic structure of the southern part of the region to a petroleum industry base, thus substantially changing the lifestyle and environment of the area.

Southeast Georgia Embayment. The Southeast Georgia Embayment area with the greatest potential for OCS oil and gas accumulation is very near shore, and the probabilities are high that oil spills from this area would come ashore in a very short time. In the spring and summer months, should a spill occur from EDS 10, 11, or 12, there is a 90 to 100 percent probability of its coming ashore, but the probability diminishes to 15 percent or lower during the fall. Spills at these sites appear more sensitive to distance from shore than at any other OCS location considered in this study. From EDS 11 a spill occurring in April could come ashore in as little as 6 days (spring average, 36 days). A spill occurring at EDS 12 during summer could come ashore in only 18 days (summer average, 60 days). This site is the one farthest from shore.

The South Atlantic experiences more severe storm conditions than those prevalent in either the Gulf of Alaska or the North Sea. Hurricanes are frequent and the highest waves in any of the OCS areas are found here; a wave of 87 feet was recorded off Georgia, and 60- to 70-foot waves are common off Cape Hatteras.

The South Atlantic coastline, particularly from Myrtle Beach nearly to Jacksonville, is unusually diverse and is largely undeveloped. Large estuaries alternate with beautiful sandy beaches and highly productive grass flats. Any OCS development affecting this exceptional section of coast must be carefully integrated with existing ecosystems. Onshore industrial sites should be directed inland–away from the biologically fragile coastal wetlands. Resort and recreational uses of beaches are also of prime importance; a spill at EDS 12, for example, would probably come ashore at St. Augustine.

Onshore effects of OCS development could be of greater magnitude in the Southeast Georgia Embayment region than in any other OCS area. However, the potential production of oil and gas from the Southeast Georgia Embayment could provide approximately 15 percent of the South Atlantic region's needs (assuming medium demand and average production).

Economic and social changes will be particularly significant in this region but will differ in magnitude between the Charleston and Jacksonville areas. For the Charleston region, most industrial and commercial activity in support of the refining and petrochemical industry would be expected to locate in or near the city because it is the only major metropolitan area within the surrounding region. As such, under high impact conditions the population of the immediate Charleston area could as much as double by 1985 and 59,000 new jobs could be created. This expansion can be equated with development of a new city: up to 37,000 new dwellings (demanding over $1 billion in mortgage financing) along with schools, public services, and utilities. Cultural, natural, and historic resources could be threatened. The surrounding region could experience a similar employment growth rate–up to 88,000 new jobs by 1985 and 110,000 by 2000.

The region comprising Jacksonville and its surroundings could accommodate high OCS impacts more readily than Charleston. Jacksonville is already undergoing extensive growth, and the existing infrastructure is better equipped to plan for and assimilate population increases. With OCS development, employment could increase by up to 37,000 by 1985 and 57,000 in 2000. Population could increase by up to 50 percent in 1985. Impacts on regional growth would be about the same as those for the local area.

Air and water pollution could be a significant problem. BOD could double in both the Charleston and Jacksonville areas, and hydrocarbon emissions would rise as a result of refinery and petrochemical development. Care must be taken to avoid violating ambient air and water quality standards.

Land requirements could easily be met in both areas, but the many swamps, salt marshes, and wetlands would require careful industrial, commercial, and residential siting.

Gulf of Alaska. The Gulf of Alaska hypothetical drilling sites are dispersed along the coastline, but they can be separated into eastern and western areas at 150°W longitude. Should a spill occur, it would have a lower probability of coming ashore in the western than in the eastern area (see Table 1-1). For instance, the maximum probability from the ADS 7 is 45 percent in summer but less than 10 percent in all other seasons, and the probabilities of a spill coming ashore from ADS 8 to 9 are no greater than 10 percent in any season. The situation is considerably worse in the eastern Gulf area where the probabilities for a spill coming ashore from all sites (ADS 1 through 6) are no lower than 40 percent in winter and exceed 95 percent in the summer. In the eastern area, the minimum time to reach shore could be as little as 3 days from ADS 3, but more representative is the 7 or 8 days from the other sites. The average times to shore are typically in the 20- to 30-day range, with seasonal variation. A critical factor is the retardation of oil weathering in northern regions due to cold water. Further, due to the reduced sunlight in winter, weathering can be expected to be slowest in the Gulf of Alaska.

Biological data are scant on the Gulf of Alaska, but fish spawning and bird nesting in coastal areas are known to be of vital ecological importance, particularly in the eastern Gulf area. If an oil spill should occur, there is a high probability of its coming ashore in the eastern Gulf in the summer months. This is the time of prime nesting for migratory birds and of the early larval life of newly spawned fish.

Storms are more frequent in the Gulf of Alaska than anywhere else in the Northern Hemisphere. The storms generally move west to southwest and then southeast. Icing could be a problem in February. The impact of earthquakes and tsunamis is another matter–major earthquakes of Richter 7 magnitude are common every 3 to 5 years, and severe Richter 8 earthquakes can be expected every 25 years. Tsunamis also are frequent and not only would create damage at fixed berth tanker sites, but in conjunction with earthquakes they can severely stress underwater storage facilities.

The OCS production of oil and gas from the Gulf of Alaska would provide more supplemental supplies of oil and gas than are needed on the west coast and in Alaska itself. This would probably mean that present patterns of oil distribution would be changed, with more oil being shifted to the Midwest and east coast.

Onshore impacts are considered for Alaska and the west coast together because no significant new refining or petrochemical development is expected in Alaska (see Table 1-3). There a significant proportion of the economic and social effects would be felt in Anchorage, the center of present Alaskan development and the likely base for much of the commerce servicing

TABLE 1-3

Summary of Onshore Impacts, West Coast: High Development[1]

Key impacts	Alaska				Washington/Oregon				Northern California			
	1985		2000		1985		2000		1985		2000	
	Local	Region	Local	Region	Local	Region	Local	Region	Local	Region	Local	Region
Primary impacts												
Number of offshore platforms (25,000 barrels per day)	19	19	60	60	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Number of refinery equivalents (200,000 barrels per day)	0	0	0	0	0.1	0.1	1.3	1.3	1.3	1.3	3.5	3.5
Number of gas processing plants (500 million cubic feet per day)	1	2	5	16	0	0	0	0	0	0	0	0
Number of petrochemical complex equivalents (1 billion pounds per year olefins)	0	0	0	0	0	0	3.0	3.0	0.5	0.5	2.9	2.9
Value of incremental construction (millions of 1970 dollars)	16	55	6	21	214	214	86	86	194	194	78	78
Aggregate impacts												
Employment (thousands)	1.1 (36)	4.4 (2)	0.8 (12)	3.7 (1)	11.0 (17)	17.3 (2)	16.5 (19)	32.2 (2)	16.4 (6)	28.3 (1)	22.0 (5)	42.7 (1)
Population (thousands)	4.2 (43)	16.0 (4)	3.4 (13)	12.9 (2)	22.0 (15)	39.0 (2)	31.4 (17)	71.0 (2)	33.7 (3)	67.3 (1)	42.4 (3)	97.0 (1)
Acreage required (thousands)	n.a.	n.a.	n.a.	n.a.	8.1 (12)	10.8 (2)	13.2 (16)	18.5 (3)	5.2 (3)	7.3 (1)	7.8 (4)	10.9 (2)
Hydrocarbon loadings (thousand tons per year)	n.a.	n.a.	n.a.	n.a.	1.7 (3)	1.8 (2)	23.4 (42)	23.6 (18)	15.1 (21)	15.5 (11)	43.3 (48)	43.7 (25)
Biological oxygen demand (million tons per year)	n.a.	n.a.	n.a.	n.a.	0.2 (7)	0.7 (1)	2.2 (53)	3.7 (4)	1.3 (15)	1.8 (2)	3.8 (12)	4.6 (3)

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[1] All imports are over base case conditions. The numbers in parentheses represent percentages over base case conditions, the first over Base Case 2 and the second over Base Case 1; where there is only one number, the percentage increase is the same for either base case.

Source: Resource Planning Associates, Inc., and David M. Dornbusch & Co., 1974, "Potential Onshore Effects of Oil and Gas Production on the Atlantic and Gulf of Alaska Outer Continental Shelf," prepared for the Council on Environmental Quality under contract No. EQ4AC002.

offshore operations. However, a number of coastal communities could feel the effects of OCS development in addition to the impacts of Trans-Alaska Pipeline construction and operation. These sparsely populated towns and villages could expect to undergo boomtown conditions with multifold increases in employment and population as early as 1985. OCS-related employment increases in Alaska as a whole could grow 20 percent by 1985.

The Puget Sound and San Francisco Bay areas can be expected to be focal points of economic and social impacts related to refining Alaskan OCS oil on the west coast. Puget Sound now has refining capacity; under OCS development, employment in this region could increase up to 20 percent by 1985 and the population up to 15 percent. Land availability will be restricted by the mountainous terrain. Air and water pollution, however, is not expected to be critical.

The San Francisco Bay area also has refining capacity. With OCS development, employment in the region could increase up to 6 percent and population to 3 percent. Land availability is restricted due to the vast amounts of wetlands and marsh along the Bay. Air pollutant emissions could increase up to 40 per cent, and care must be taken to avoid violating ambient standards. Water pollution is not expected to be a problem.

The West Coast analyses assume that all Gulf of Alaska OCS crude oil going to the Puget Sound and San Francisco regions would require additional refining capacity beyond that constructed for North Slope or imported crude–construction that is likely to take place earlier than Alaskan OCS development. Thus, to the extent that Gulf of Alaska crude is not needed to meet west coast demand and is shifted to other parts of the country, the impacts described above are overestimated.

OCS Technology and Practices

The technology and practices used in locating and exploiting OCS oil and gas resources continue to evolve. Past experience must be balanced with future expectations in judging the adequacy of OCS technology and the ability of industry to use it safely in new OCS areas. Following the Santa Barbara blowout, the U.S. Geological Survey modified OCS regulations in several significant ways. Further, industry appears to be responding in other areas not directly covered by changes in the OCS orders.

In general, the Council believes that OCS oil and gas technology can operate safely under conditions similar to those in the Gulf of Mexico and the North Sea. However, storm conditions in the Atlantic and storm and seismic conditions in the Gulf of Alaska present more severe threats to personnel safety and environmental protection than the petroleum industry has faced before. Industry's ability to use technology safely is an essential element in minimizing environmental damage from oil and gas operations in new OCS areas. Careful attention to human factors, systems analysis, and personnel training are very important.

Chapter 8 assesses OCS technology and practices in detail. The following recommendations for improvement are based on that assessment:

- The continuing search for better technology must build upon an improved understanding of the role of human factors in equipment design and must be coupled with thorough training of the equipment operators. The Council recommends that human factors engineering be employed to the fullest extent in the design of OCS oil and gas equipment. The Department of the Interior should review proposed designs for facilities to be used in new OCS areas and encourage the incorporation of man–machine engineering principles.
- Training programs may not be required for all types of jobs, but certainly for the most critical, curriculum standardization and personnel certification should be required. The Council recommends that the Department of the Interior establish minimum Federal standards for critical OCS operator personnel and certify or provide for appropriate accreditation of the training programs.
- Rapid, accurate measurement of downhole pressure appears important in improving the ability to maintain well control and to reduce the possibility of blowouts. The Council recommends that the Deaprtment of the Interior determine which technologies could improve the measurement of the formation pressure near the drill bit and incorporate them into the OCS orders.
- Serious consideration must be given to postponing leasing in an OCS region where oil cannot be safely produced and safely transported to markets because of significant threats of earthquakes, tsunamis, and severe storms. The Council recommends that the Departments of the Interior and Transportation coordinate their evaluation and approval procedures for drilling

platforms for new OCS areas. They should prepare detailed performance requirements for such platforms, considering fully the natural hazards in these areas.

- The Council recommends that the Deaprtment of the Interior, in coordination with the Environmental Protection Agency, develop more detailed guidelines for the disposal of drilling muds, drill cuttings, and other materials, considering fully the results of the Bureau of Land Management monitoring studies of ocean disposal of these materials in new OCS areas.
- The Council recommends that the Department of the Interior develop and incorporate in OCS orders detailed performance requirements for production platforms and associated equipment to be used in new OCS areas, with full consideration of natural hazards. The Department should develop in-house capability, or should contract with a qualified independent firm, to evaluate the adequacy of the proposed designs to guarantee structural integrity subject to natural and manmade forces.
- The Council recommends that subsea production equipment be used in new OCS areas where it would provide a higher degree of environmental protection and reduce conflict between oil and gas operations and competing uses of the ocean.
- The Council recommends that the Department of the Interior develop detailed performance requirements for surface-actuated subsurface safety valves and require their use on all production wells in new OCS areas where technically feasible. The Department should encourage the development of such valves with higher pressure ratings and with improved reliability of operation over the life of the devices.
- In undeveloped areas like the Atlantic and Gulf of Alaska OCS, environmental loadings of oil and other materials should be kept at the lowest levels possible at least until environmental baseline studies such as those recently initiated by the Bureau of Land Management determine the environmental risk from such materials. The Council recommends that the Department of the Interior and the Environmental Protection Agency, in cooperation, establish effluent standards for waste water discharge from OCS drilling, production, and associated operations. Strong consideration should be given to requiring installation of the best commercially available control technology for oil–water separation in new OCS areas.
- The Council recommends that the Department of the Interior develop detailed performance requirements for safety practices for well workover and servicing operations on production platforms and incorporate them in OCS orders for the new areas. The Department should consider regulations encouraging the use of improved technology to minimize the threat of blowouts during workover and service operations.
- The Council recommends that the Departments of the Interior and Transportation and the Environmental Protection Agency develop and implement a common reporting system for all accidents associated with OCS operations. This improved system should provide complete unambiguous reporting, with special attention to the analysis of cause–effect relationships.
- The Council recommends that the Departments of the Interior and Transportation develop detailed performance requirements for OCS pipeline protection and undertake the development of pipeline integrity monitors to detect incipient failures in OCS pipelines.
- The Council recommends that the Department of the Interior, in cooperation with other Federal agencies and the affected states, undertake advanced planning for pipeline corridor siting as soon as the location of potentially producing OCS areas is known and designate corridors which avoid or minimize, to the maximum extent possible, intrusion into environmentally sensitive areas in the marine and coastal regions of new OCS areas.
- The Council recommends that the Coast Guard require that new tankers in the U.S. coastal trade (which would include tankers used to carry OCS oil to shore) be constructed with segregated ballast capacity preferably with double bottoms when ship safety would not be jeopardized. Existing tankers used to carry OCS oil to shore should be prohibited from discharging oily ballast water to the oceans. In addition, the Coast Guard should seriously consider requiring new and existing ships to employ advanced accident prevention technologies to improve vessel maneuverability and communications.
- Decisions on offshore oil storage in the Atlantic and Gulf of Alaska OCS must fully consider the potential impacts of severe storm and seismic

conditions. The Council recommends that the Departments of the Interior and Transportation develop detailed performance standards for offshore storage facilities and incorporate them into OCS orders for the new areas.

- The Council recommends that the Federal Government and industry continue efforts to improve oil spill containment and cleanup. The Council recommends further that the Departments of the Interior and Commerce and the Environmental Protection Agency cooperatively consider the identification of critical environmental regions in new OCS areas and the incorporation of appropriate measures into the National Oil and Hazardous Substances Pollution Contingency Plan.

Planning, Coordination, and Regulation

Effective planning for and regulation of OCS activities involve a number of elements: a rational allocation of regulatory rights and responsibilities and an efficient means of coordination among entities sharing the authority; provision for ensuring that necessary information is obtained and analyzed prior to regulatory actions and that the public has enough information to allow informed participation in the process; ongoing systematic evaluation of OCS technologies and practices and incorporation into OCS regulations specific requirements necessary for environmentally sound operations; enforcement of the requirements through effective inspections and sanctions for noncompliance; and means for compensation of injured parties when mishaps occur.

These elements are discussed in detail in Chapter 9 and are the basis for the following recommendations:

- The Council recommends that states affected by new OCS development strengthen their coastal zone management programs by developing special technical expertise on all phases of OCS development and its onshore and offshore impacts. Such augmented state coastal zone management agencies should attempt to ensure that state interests and regulatory authorities are fully coordinated with Federal OCS technical and management activities. Federal agencies should make every effort to cooperate with state coastal zone management agencies on an ongoing basis and at all stages of the management process.
- The NEPA process can be an important focus of Federal–state coordination concerning OCS development. The Council recommends that state coastal zone management agencies be given the opportunity to cooperate with Federal agencies in designing and preparing environmental studies used as input to the environmental review process, in addition to commenting on draft environmental impact statements.
- The Coastal Zone Management Act provides a framework for Federal-state cooperation in planning for onshore development induced by OCS operations, particularly siting of pipelines, refineries, and other facilities in the coastal zone. The Council recommends that the Secretary of Commerce require that state coastal zone plans consider refineries, transfer and conversion facilities, pipelines, and related development as a condition of approval. State coastal zone management agencies and concerned Federal agencies should jointly participate in developing these portions of the plans.
- Many Federal agencies, each with specific missions, have regulatory and operating authority affecting the OCS. There is no formal mechanism for coordinating the exercise of their responsibilities. The Council recommends that the proposed Department of Energy and Natural Resources be established. This centralization of authority would increase the effectiveness of Federal efforts in achieving closely related regulatory objectives in the OCS.
- The Council recommends that impact statements on environmentally significant OCS activities include in the discussion of "the range of potential uses of the environment" analyses of possible alternative uses of specific OCS, near-shore, and onshore areas. In addition, the statements should include discussion of onshore impacts. In commenting on draft statements, Federal agencies, states, and interested parties should give particular emphasis to those issues.
- OCS decisionmaking could also be enhanced through regional, programmatic impact statements. The Council recommends that programmatic statements be prepared on a regional basis by all Federal agencies proposing environmentally significant activities on the OCS. Comprehensive OCS planning could be approached through reconciling various agency statements in the circulation and comment process.

- The Council recommends that the Department of the Interior, in consultation with other appropriate Federal agencies, determine the kinds of information and analyses necessary for adequate assessment of environmental factors at all stages of leasing and development. The Department should take measures to obtain such information, including acquisition and analysis of high-resolution, near-surface seismic reflection data for the purpose of determining the nature and magnitude of geologic hazards prior to tract selection.
- The Council recommends that the Department of the Interior consider the competitive consequences of requiring disclosure of certain industry data and analyses. The Department should weigh those consequences against the benefits to be obtained and develop standards for governing such disclosures. In making that balance, it should consider particularly the need for informed public participation in the NEPA process.
- The Council recommends that, in order to deter violations of OCS orders rather than simply shortening the time that operators take to correct noncompliance, the Secretary of the Interior propose sanctions requiring fixed shutin periods and administrative fines as enforcement measures.
- The Council recommends that the Department of the Interior determine the frequency and type of inspections necessary to verify compliance during all phases of OCS operations. It should establish inspection teams and procedures in light of those determinations and the scale of OCS development in various regions. State agencies should be invited to participate in these inspection efforts. In addition, the Department should establish a formal training program for the inspection staff.
- Citizen suit provisions, which allow interested persons to sue to remedy violations of Federal regulations or permit conditions, can provide a useful compliance mechanism. The Council recommends that the Secretary of the Interior seek the establishment of such a right under the OCS Lands Act.
- The Federal Government should carefully consider the full economic and environmental implications of various types of liability–fault or nofault–and various means of ensuring adequate compensation such as liability insurance for operators or a revolving fund financed through charges on operators. The Council recommends that a comprehensive Federal liability system for OCS-related oil spill cleanup and damages be established through new legislation.

Research Needs

In the course of this study, the Council found many gaps in biological, physical, chemical, technological, economic, and social data. These gaps must be closed and the research results must be usefully incorporated in improving OCS management decisions. We have mentioned earlier in this chapter the need for well-designed biological baseline and monitoring studies. Questions of when, where, how, and what to measure also must be answered. Other biological research needs are outlined below and in Chapter 6:

- Population life histories for many species, including identification of survivorship, fecundity, larval lifestyle, migrations, and behavior.
- Community response at the species level following polluting incidents or in controlled experiments.
- Adaptations of organisms to oil exposure, including genetic changes.
- Impacts of oil during sensitive stages of species development.
- Effects of oil on commercial fisheries.

OCS technology should continue to evolve in order to ensure lower levels of risks from operations in the Atlantic and Gulf of Alaska. Research can contribute to understanding the behavior of offshore structures under storm and seismic forces, to reducing chronic pollution from OCS operations, to improving the integrity of offshore pipelines, and to integrating knowledge of human factors engineering into design. Improved Federal performance standards for OCS operations should draw upon the results of such research.

The Council believes that further study of onshore impacts of OCS activities is needed. Studies focusing on the socioeconomic impacts of OCS development at specific sites will be needed by local decisionmakers. Availability of land for development, impacts on the quality of life, shifts in population and employment patterns–all must be evaluated on a local basis to be of use in state and local planning.

REFERENCES

1. The President's Energy Message of April 18, 1973.
2. 67 Stat. 462, 43 U.S.C. §1313.
3. 83 Stat. 852, 42 U.S.C. §4321.
4. 86 Stat. 1280, 16 U.S.C. §1451.
5. 86 Stat. 816, 33 U.S.C. §1251.
6. 86 Stat. 1052, 16 U.S.C. §1431.

Chapter 2. Oil and Gas Resources

GEOLOGY OF OIL AND GAS ACCUMULATION

Oil and natural gas are hydrocarbons, or fossil fuels, as are coal, shale oil, and tar sands. Natural gas is primarily methane, the simplest of the hydrocarbon compounds, ranging from natural gasolines to very viscous oils. Intermediate between natural gas and crude oil are natural gas liquids which are mixtures of propane and heavier compounds. They are extracted during the production of natural gas.

Oil and natural gas result from the slow chemical change of biological material (dead marine animal and plant debris) that was deposited in thick layers of sediments during the last 600 million years on what was then the earth's surface. After oil and natural gas compounds formed in an oxygen–deficient environment, they migrated upward through the water-saturated sedimentary rocks (the hydrocarbons are less dense than water) and, eventually, either escaped into the atmosphere or were trapped by a layer of impermeable rock. At a minimum, large deposits of petroleum require the presence of, or proximity to, both thick sedimentary rock strata that were deposited in an appropriate marine environment and suitable geologic traps.

Although oil and natural gas accumulations are found throughout the world, they are distributed very unevenly in the earth's sedimentary rocks—in fact, a large proportion of the oil and gas discovered to date has been located in only a few places.

> More than 85 percent of the world's hydrocarbon production plus reserves occurs in less than 5 percent (238 fields) of all producing accumulations. Even more remarkable, 65 percent of the hydrocarbons (petroleum plus gas) occurs in slightly over 1 percent of all fields—the 55 "supergiants" (a billion barrels or a trillion cubic feet or more); and an astounding 15 percent occurs in only two immense accumulations in the Middle East region (Ghawar field in Saudi Arabia and Burgan field in Kuwait). [1]

Whether oil and gas are present in the Atlantic and Gulf of Alaska OCS areas is highly speculative. There may be large commercial reservoirs in these regions exploitable with today's technology or only small, noncommercial reservoirs or trace amounts. Because geological information on these OCS areas is limited, estimates are at best educated guesses and vary widely depending upon the method of prediction.

The following sections summarize data on world and regional production, reserves, and estimated resources.

OIL AND GAS RESERVES AND RESOURCES OF THE WORLD

Production of oil and natural gas is widely international. Sixty countries have proved oil reserves* and all but three are producing. Fifty-five countries have proved natural gas reserves, and over 40 are now marketing appreciable quantities. A summary of the world oil and gas reserves and annual production levels is given in Table 2-1; details may be found in Appendix D.

The Middle East accounts for over 53 percent of the world's total proved oil reserves and 55 percent of the world's proved oil reserves offshore. [2] It also accounts for 18 percent of total proved gas reserves and 51 percent of the proved gas reserves offshore. Saudi Arabia dominates proved oil reserves both onshore and offshore, and Iran dominates proved gas reserves both onshore and offshore. Following the Middle East, the U.S.S.R. accounts for 11 percent of the total proved oil reserves, and three northern

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Proved or *measured reserves* are those identified resources from which an energy commodity can be economically and legally extracted and whose location, quality, and quantity are known from geological evidence supported by engineering measurements. Further definition of these and other terms used to classify mineral resources is given in Appendix E.

African nations—Algeria, Libya, and Egypt—account for another 12 percent of the total proved oil reserves.

The U.S.S.R. has by far the largest proved natural gas reserves, over 26 percent of the world's total reserves. [3] Of the 30 largest gas fields in the world, 19 are in the Soviet Union and most have been discovered in the past decade. [4] The United States, with only 5.5 percent of the proved oil reserves, is second in natural gas reserves. The United States accounts for 18 percent of the world's natural gas reserves and has 3 of the 30 largest gas fields in the world.

Offshore production is becoming increasingly important throughout the world. Offshore proved reserves of oil and gas account for nearly 24 and 26 percent, respectively, of the total proved reserves, as seen in Table 2-1. Exploration is underway in coastal waters of 100 countries, and offshore production is or soon will be underway in 40 countries, according to a recent United Nations report. [5] Offshore oil production worldwide was approximately 9.1 million barrels per day, about 18 percent of total production, and offshore gas production worldwide was 5.0 trillion cubic feet, about 10 percent of total production in 1972. [6] The three important offshore areas—the Persian Gulf, Venezuela, and the Gulf of Mexico—accounted for nearly 80 percent of the total offshore production in 1972.

With discovery of oil in the North Sea less than 5 years ago, one of the world's most abundant oil provinces outside the Middle East was found. Over 12 billion barrels of oil and 50 trillion cubic feet of natural gas have already been found, and some predict that at least 30 billion barrels of oil will ultimately be discovered. [7] The average size of the five largest oil fields in the North Sea is nearly 2.5 times as large as the five largest oil fields in the Gulf of Mexico. Production rates for the North Sea fields are as much as 5 to 10 times higher than those for the large Gulf fields. [8] It is estimated that production levels should grow to 3 to 5 million barrels per day in the early 1980's. [9]

In addition to proved and indicated-inferred reserves, estimates of undiscovered economically recoverable resources provide another yardstick against which the potential of U.S. OCS oil and gas resources

TABLE 2-1

World Oil and Gas Reserves and Production[1]

	Proved Reserves Total[2]		Proved Reserves Offshore[3]		Annual Production	
	Oil	Gas	Oil	Gas	Oil[4]	Gas[5]
Western Hemisphere	79.6	405.7	48.4	97.5	15.7	27.9
(United States)	(36.8)	(271.5)	(10.1)	(44.5)	(9.5)	(22.0)
Western Europe	12.1	178.4	12.0	64.0	0.4	2.9
Eastern Europe, U.S.S.R. and People's Republic of China	98.0	664.4	1.5	1.0	8.9	9.2
Middle East	355.8	344.2	87.0	250.0	17.2	2.9
Africa	106.4	189.0	4.7	—	5.7	1.4
Asia-Pacific	14.9	101.2	5.0	77.0	1.8	0.7
Total world	666.9	1,882.9	158.0	488.0	49.7	44.9

[1] Oil in billion barrels, gas in trillion cubic feet. See Appendix D for details.

[2] As of the end of 1972.

[3] As of March 1973.

[4] For 1972.

[5] For 1970.

Sources: Federal Power Commission, *National Gas Supply and Demand* 1971-1990 (Washington: U.S. Government Printing Office, 1972); Frank J. Gardner, "1972: Year of the Arab," *Oil and Gas Journal*, Dec. 25, 1972, p. 80; Nixon Quintrelle, "Reserves Lessen Onshore and Increase Offshore," *Offshore*, April 1973, p. 59; University of Oklahoma Technology Assessment Group, *Energy Under the Oceans* (Norman: University of Oklahoma Press, 1973).

can be measured.* Recent estimates of undiscovered economically recoverable resources range from 2,000 to 2,500 billion barrels worldwide, of which the United States may have from 100 to 400 billion barrels.

OIL AND GAS RESERVES AND RESOURCES OF THE UNITED STATES

Oil was produced commercially in the United States from wells drilled on land over 100 years ago. The first wells offshore began operations in 1896 in Southern California.

Domestic production of oil and gas offshore has been increasing steadily and in 1972 rose to over 12 percent of total national production (see Table 2–2) Table 2–3 presents domestic proved reserves both onshore and offshore. As shown, offshore petroleum liquid reserves account for nearly 16 percent of the total. Proved reserves of natural gas offshore account for about 18 percent of the total. (See Appendix E for further details.)

Estimates of the indicated-inferred reserves and undiscovered economically recoverable petroleum resources vary widely. The USGS estimates that indicated and inferred reserves of crude oil and natural gas liquids range from 25 to 45 billion barrels and of natural gas range from 130 to 250 trillion cubic feet. [10] The USGS also estimates that undiscovered economically recoverable resources of crude oil and natural gas liquids range from 200 to 400 billion

TABLE 2-2

U.S. Annual Offshore Oil and Gas Production

	Petroleum liquids[1]				Natural gas[2]			
	1960	1965	1970	1972	1960	1965	1970	1972
Alaska								
State waters	–	–	70	64	–	–	.082	.075
OCS	–	–	–	–	–	–	–	–
California								
State waters	28	43	79	73	.001	.041	.059	.035
OCS	–	–	25	23	–	–	.012	.010
Louisiana								
State waters	38	54	64	20	.138	.226	.532	.185
OCS	50	145	334	387	.270	.645	2.268	2.891
Texas								
State waters	1	1	1	1	.031	.028	.132	.009
OCS	–	–	2	2	–	–	.132	.148
Offshore total								
State waters	67	98	215	157	.167	.293	.805	.304
OCS	50	145	361	412	.273	.646	2.412	3.049
Total	117	243	576	569	.440	.939	3.218	3.353
U.S. total	2,574	2,849	3,517	3,462	12.771	16.040	21.921	22.910
OCS percentage of U.S. total	2	5	10	12	2	4	11	13

[1] In billion barrels. Includes both crude oil and natural gas liquids.

[2] In trillion cubic feet.

Source: U.S. Geological Survey, Department of the Interior, *Outer Continental Shelf Statistics* (Washington: U.S. Government Printing Office, 1973).

**Indicated reserves* are those for which quality and quantity are computed partly using measurements, samples, and production data and partly by projection based on geological evidence. *Inferred reserves* are those for which quantitative estimates are based largely on broad knowledge of the geologic character of the deposit and for which there are few, if any, samples or measurements. *Undiscovered economically recoverable resources* are those which may be reasonably expected to exist in favorable geological settings but which have not yet been identified by drilling. Exploration that confirms their existence and reveals quantity and quality will permit their reclassification as a reserve which can be economically extracted. (See Appendix E for further details.)

TABLE 2-3

U.S. Oil and Gas Proved Reserves[1]

	Petroleum liquids[2]	Natural gas[3]
Onshore	40.7	218.3
Lower 48	31.0	189.8
Alaska	9.7	28.5
Offshore	7.6	47.8
Lower 48	6.9	46.0
Gulf of Mexico	(4.0)	(43.3)
California	(2.9)	(2.7)
Alaska	0.7	1.8
Total	48.3	266.1

[1] Estimates revised as of Feb. 14, 1974.

[2] In billion barrels. Includes both crude oil and natural gas liquids. Crude oil accounts for about 80 percent of the total petroleum liquid reserves.

[3] In trillion cubic feet. As of the end of 1972, cumulative production of petroleum liquids was 115.3 billion barrels, and cumulative production of natural gas was 437.7 trillion cubic feet.

Source: U.S. Geological Survey, Department of the Interior, "U.S. Petroleum and Natural Gas Resources," March 1974.

barrels and of natural gas range from 1,000 to 2,000 trillion cubic feet (see Tables 2-4 and 2-5 for selected estimates).

Although the range of the USGS estimates includes most of the other estimates, some estimates, especially those by M. K. Hubbert, are significantly lower. [11] Hubbert's estimates suggest that the United States has already peaked in crude oil production and will soon peak in natural gas production. Because 115 billion barrels of petroleum liquids has been produced (by the end of 1972), his estimate that 231 billion barrels of liquids will ultimately be produced implies that one-half the petroleum liquids has already been extracted. Further, using the USGS estimates of 48 billion barrels of measured reserves and 25 to 45 billion barrels of indicated-inferred reserves, Hubbert's projection would mean that there is only 20 to 40 billion barrels left in the undiscovered recoverable category. His projection that 1,200 trillion cubic feet of natural gas will be produced implies that about 37 percent of the Nation's natural gas has been extracted.

The recent NPC and Moore resource estimates are somewhat higher than the Hubbert estimates. [12] The NPC petroleum liquids and natural gas estimates are 37 and 55 percent higher, respectively, than the Hubbert estimates. The Moore petroleum liquids and natural gas estimates are about 90 and 30 percent higher, respectively. The lower range of the USGS estimates is roughly comparable to the NPC and Moore estimates, but the higher USGS range is significantly above the other estimates. For example, USGS estimates for petroleum liquids range from about 70 to 165 percent above the Hubbert estimate, and the natural gas estimates range from about 50 to 150 percent higher. The USGS natural gas estimates range from 50 to 150 percent above the Hubbert estimate of 1,200 trillion cubic feet.

The wide variations in resource estimates arise, in part, from the use of different predictive techniques. There are two major approaches—geological and mathematical. Although both use oil and gas exploration and production statistics, geological methods explicitly relate them to the area or volume of rock strata potentially containing oil or gas and to the technology used to extract the resources. Mathematical methods project future trends using past statistics, thus only implicitly considering evolutionary trends in geological and technological factors. The National Petroleum Council, U.S. Geological Survey, Potential Gas Committee (PGC), and Weeks all use the geological method. Elliot and Linden, Hubbert, and Moore use mathematical methods. [13]

The Atlantic OCS

Geology of the Atlantic OCS. The Atlantic outer continental shelf is relatively broad and slopes gently. Along most of the eastern United States it is 75 to 100 miles wide (to a depth of 200 meters), although the shelf is between 250 and 300 miles wide off New England, is about 20 miles wide off Cape Hatteras, and is less than 10 miles wide off southern Florida.

The thick sediments that accumulated under the Atlantic OCS consist of sand and mud eroded from the eastern United States—especially from the Appalachian Highlands—and carried to sea by rivers. Carbonate rocks are also known to be present. The geology of the Atlantic OCS generally resembles the onshore geology of the upper Gulf coast—east Texas, northern Louisiana, southern Arkansas, and Mississippi. [14]

From Cape Cod to Florida, the shelf is a seaward extension of the Atlantic Coastal Plain (see Figure 2-1). Here the sedimentary rock thickens from less than 3,000 feet near the coast to 10,000 feet, in places to more than 25,000 feet near the edge of the shelf. [15] Major geological features in the area are the Baltimore Canyon Trough stretching from Long Island,

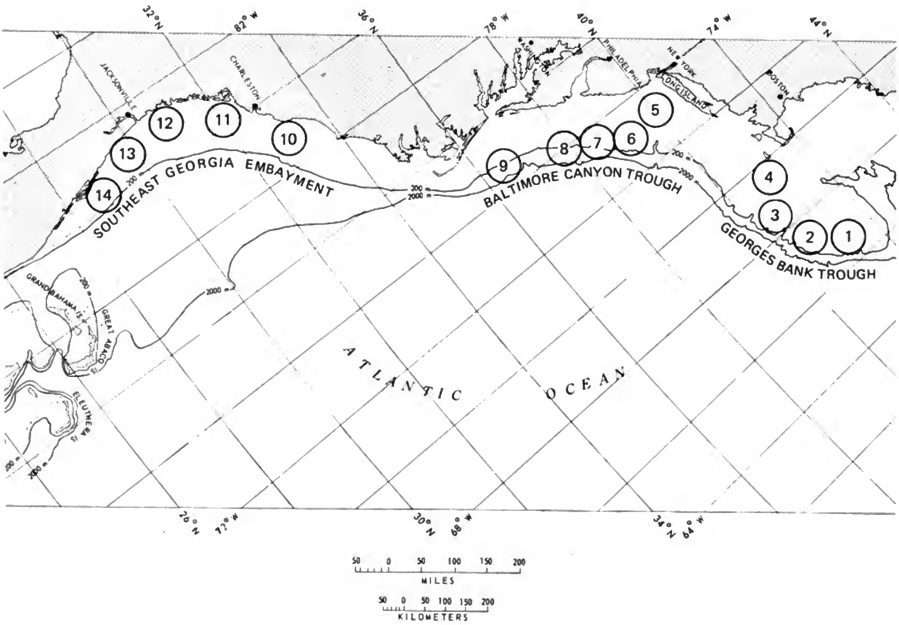

Figure 2-1. Atlantic Hypothetical Drilling Sites

TABLE 2-4

Selected Estimates of Total Petroleum Liquids[1]

	USGS[2]	NPC[3]	Hubbert	Moore[4]
Onshore				
Lower 48	270-390	217		
Alaska	40-70	29		
Subtotal	310-460	246		
Offshore				
Gulf of Mexico	30-50	19		
Pacific	10-20	17		
Atlantic	10-20	6		
Alaska	30-60	29		
Subtotal	80-150	71		
Total	390-610	317	231	436

[1] In billion barrels. These total resource estimates include cumulative production, reserves (both measured or proved and indicated-inferred), and undiscovered economically recoverable resources of both crude oil and natural gas liquids. (See Appendix E for a description of the Department of the Interior mineral resource classification.)

[2] U.S. Geological Survey, Department of the Interior, "U.S. Petroleum and Natural Gas Resources," March 1974. (See Appendix E for details.)

[3] The National Petroleum Council, composed of industry experts, which advises the Secretary of the Interior. National Petroleum Council, *U.S. Energy Outlook* (Washington: National Petroleum Council, 1972). The NPC estimates of ultimately discoverable oil-in-place (an industry term for the crude oil resource which exists in the ground and can ultimately be discovered) was converted to recoverable resources using a cumulative 33 percent recovery efficiency. Then 49 billion barrels of natural gas liquids (assuming an 80 percent recovery of 61 billion barrels) was allocated to the different areas following the distribution of natural gas resources presented in Table 2-5.

[4] Moore's estimate of recoverable crude oil (353 billion barrels) includes a constantly increasing recovery efficiency—projected to 42 percent by 2000 and ultimately to 60 percent—much higher than efficiencies used by others. C.L. Moore, "Analysis and Projection of Historic Patterns of U.S. Crude Oil and Natural Gas," in *Future Petroleum Provinces of the United States* (Washington: National Petroleum Council, 1970).

N.Y., to Virginia, the Cape Fear Arch, the Southeast Georgia Embayment stretching from South Carolina to Cape Canaveral, and the Blake Plateau in much deeper water seaward of the Southeast Georgia Embayment.

Because two of these, the Baltimore Canyon Trough and the Southeast Georgia Embayment, have thick sedimentary deposits and are generally covered by less than 500 feet of water, they receive special attention in this study. In the Baltimore Canyon Trough, the sedimentary deposits may be up to 40,000 feet thick. Over 90,000 cubic miles of sediments with potential for oil and gas are present in the trough. [16]

The Blake Plateau, which may have 30,000-foot thick deposits, is 2,500 to 3,000 feet beneath the ocean surface. These depths are beyond current technology, so the Blake Plateau was not considered in this study.

Southeast of New England is another basin with petroleum potential—the Georges Bank Trough. "Basement rocks," the hard, brittle rocks like granite and marble or well-consolidated sedimentary rocks, are exposed along the New England coast, but thick sedimentary sections lie offshore. The Georges Bank Trough is just such a deposit about 175 miles long and 80 miles wide in a depression of basement rocks. Its center lies about 130 miles east of Nantucket, Mass. The sediments there may be 26,000 feet thick. [17] In the entire basin, 30,000 to 60,000 cubic miles of sediments may contain oil and gas. [18]

North of Georges Bank is the western Nova Scotia shelf, an area which appears geologically similar to Georges Bank. Exploration for oil and gas has recently begun on the Nova Scotia shelf; 89 exploratory wells have been drilled offshore. This drilling has demon-

TABLE 2-5

Selected Estimates of Total Natural Gas[1]

(In trillion cubic feet)

	USGS[2]	NPC[3]	Hubbert	Moora[4]
Onshore				
Lower 48	1,200-1,780	1,210		
Alaska	150-270	155		
Subtotal	1,350-2,050	1,365		
Offshore				
Gulf of Mexico	250-425	220		
Pacific	15-25	25		
Atlantic	55-110	60		
Alaska	170-340	185		
Subtotal	490-900	490		
Total	1,840-2,950	1,855	1,200	1,550

[1] These total resource estimates include cumulative production, reserves (both measured or proved and indicated-inferred), and undiscovered economically recoverable resources of natural gas. See Appendix E for a description of the Department of the Interior mineral resource classification.

[2] U.S. Geological Survey, Department of the Interior, "U.S. Petroleum and Natural Gas Resources," March 1974. (See Appendix E for details.)

[3] The National Petroleum Council, composed of industry experts, which advises the Secretary of Interior. National Petroleum Council, *U.S. Energy Outlook* (Washington: National Petroleum Council, 1972). The NPC estimate relied heavily on the 1970 Potential Gas Committee estimate. The NPC estimate did not distinguish between onshore and offshore Alaskan gas; thus 277 trillion cubic feet of nonassociated gas was allocated in proportion to the USGS estimate of gas production onshore and offshore Alaska. Further, 357 trillion cubic feet of associated and dissolved gas was allocated to the different areas following the distribution of crude oil resources presented in Table 2-4.

[4] C.L. Moora, "Analysis and Projection of Historic Patterns of U.S. Crude Oil and Natural Gas," in *Future Petroleum Provinces of the United States* (Washington: National Petroleum Council, 1970).

strated that hydrocarbons, especially natural gas and natural gas liquids, are present in sediments similar to those of the Georges Bank. To date, four wells have indicated commercial quantities of natural gas and natural gas liquids. [19]

Generally, the results of onshore exploration along the Atlantic Coastal Plain have been so discouraging that little exploratory drilling has taken place either onshore or in state waters. In southern Florida, limited exploration has yielded only four small crude oil fields and no natural gas fields.

Estimated Resources. Estimates of petroleum resources in the Atlantic OCS do not distinguish among the Georges Bank Trough, the Baltimore Canyon Trough, and the Southeast Georgia Embayment. Rather, they treat the Atlantic OCS as one province stretching from the Canadian border to Florida (see Table 2-6). Estimates of undiscovered economically recoverable crude oil and natural gas range from 5 to 20 billion barrels and from 35 to 110 trillion cubic feet, respectively.

The Gulf of Alaska OCS

Geology of the Gulf of Alaska OCS. The outer continental shelf in the Gulf of Alaska is considered the most favorable area of the Alaskan OCS for oil and gas production, in part because it has a climate less hostile than that off the North Slope and in the Bering Sea. The prospect of oil and gas accumulations is suggested by onshore geology and inferred offshore geology. Many oil and gas seeps exist onshore; these have been known since 1896. From 1900 to 1933, 41 wells were drilled onshore. A small oil field, discovered near Katalla in 1902 and abandoned in 1933, produced 154,000 barrels of a paraffin-based oil from 18 shallow wells. [20] Since 1954, 26 wildcat wells have been drilled, including a dry well in the OCS near Middleton Island, 70 miles south of the mainland. [21]

The Pacific Margin Tertiary Province extends 900 miles along the southern coast of Alaska, covering 40,000 square miles (see Figure 2-2). Only 6,000

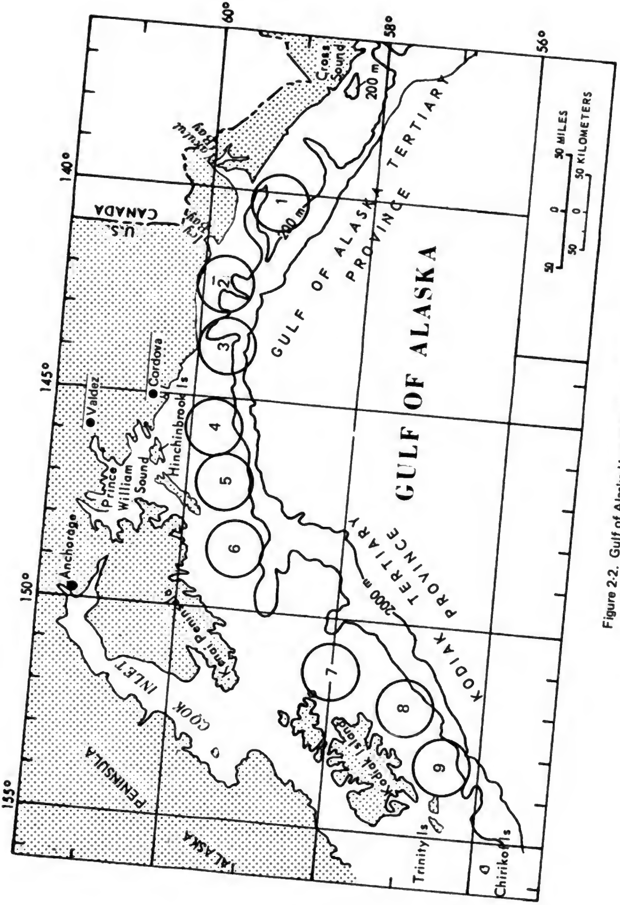

Figure 2-2. Gulf of Alaska Hypothetical Drilling Sites

TABLE 2-6

Estimates of Undiscovered Economically Recoverable Oil and Gas in the Atlantic OCS

	Crude oil (billion barrels)	Natural gas (trillion cubic feet)
USGS (1974)	[1] 10-20	55-110
NPC (1972)[2]	4.8	54.5
NPC-PGC (1970)[3]	19	46
PGC (1976)[4]	—	35

[1] The USGS estimate includes both crude oil and natural gas liquids, so it may be 15 to 20 percent higher than for crude oil only. U.S. Geological Survey, Department of the Interior, "U.S. Petroleum and Natural Gas Resources," March 1974.

[2] The NPC estimate includes 10.75 billion barrels of oil-in-place for the Atlantic offshore area north of latitude 33°, 1.75 billion barrels for the offshore area south of 33° to the Florida boundary, and 1.90 billion barrels for the Florida offshore. National Petroleum Council, *U.S. Energy Outlook* (Washington: National Petroleum Council, 1972). The 14.4 billion barrels total was converted to ultimate production with a 33 percent recovery efficiency.

[3] The NPC Committee on Possible Future Petroleum Provinces presents independent estimates of recoverable oil resources but uses the Potential Gas Committee's 1968 estimate for ultimate natural gas production from the Atlantic OCS. National Petroleum Council, *Future Petroleum Provinces of the United States* (Washington: National Petroleum Council, 1970).

[4] The Potential Gas Committee estimate includes the entire Atlantic offshore area, except Florida, to a depth of 1,500 feet. U.S. Geological Survey, Department of the Interior, "Comparison and Discussion of Some Estimates of United States Resources of Petroleum Liquids and Natural Gas," Appendix 2 in *Outer Continental Shelf Policy Issues*, Senate Committee on Interior and Insular Affairs, 92nd Cong., 2nd Sess., ser. 92-27, pt. 1 (1972).

square miles (along the coast from Cordova to Yakutat) is onshore, with most of the remainder lying in the outer continental shelf. The Tertiary sediments are thick—10,000 to 15,000 feet—with a volume of 50,000 to 75,000 cubic miles. [22]

Offshore exploration of the province began in the mid–1960's, and an extensive amount of seismic data (25,000 to 75,000 line–miles*) has been collected by the industry. In addition to other geophysical surveys, a shallow, seafloor coring† program involving 60 cores (to a maximum depth of 300 feet) was conducted in summer 1971. Within the central section of the Tertiary Province, over 50 geological structures capable of trapping hydrocarbons have been delineated. Some of these structures are large enough to be classified as "giants"—they could contain at least 1 billion barrels of oil. [23]

Another cause for interest in the Gulf area is its proximity to the Cook Inlet Province. Commercial quantities of oil were discovered on the Kenai Peninsula in 1957. Since then 6 oil fields which may contain 2.6 billion barrels and 18 gas fields which may contain 5.0 trillion cubic feet have been discovered. Undiscovered recoverable oil and gas resources may be three times as high. [24] In 1972, 64 million barrels of petroleum liquids and 75 billion cubic feet of gas were produced from offshore wells in Cook Inlet. [25]

In February 1968, the Bureau of Land Management called for nominations of tracts for a possible oil and gas lease sale in the Gulf of Alaska. The proposed lease sale covered the central section of the Pacific Margin Tertiary Province. Nominations were closed in December 1968, but the hearings on the proposed sale were postponed and there has been no subsequent action.

Estimated Resources. No definitive estimates have been made of oil and gas resources in the Gulf of Alaska OCS. Estimates for the Gulf have been included in those for southern Alaska, the Alaska OCS, and total Alaska (onshore plus offshore). Several approximations of the resources are presented in Table 2–7. The undiscovered economically recoverable oil resources in the OCS area appear to range from 3 to 25 billion barrels, although most predictions are at the lower end of the range. Natural gas resources may range from 15 to 30 trillion cubic feet. Proved crude oil reserves are less than 1 billion barrels, and natural gas reserves are less than 2 trillion cubic feet in nearby Cook Inlet. [26]

HYPOTHETICAL OIL AND GAS LOCATIONS

In order to estimate the potential environmental and economic impacts which might result from discovery and development of oil or gas in the two OCS areas, it was necessary to assume the approximate location of potential oil and gas accumulations. Many effects of potential OCS oil and gas development are site–specific, e.g., dispersion of oil spills depends on local winds, ocean currents, and tides. Similarly, analysis of the onshore environmental effects of pipeline corridors and refinery construction and operation requires an assumption of the approximate location of potential OCS oil and gas fields.

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*A "line–mile" of seismic data is that amount of data accumulated during 1 mile of movement by the reconnaissance ship.

†"Coring" is explained in Chapter 4.

TABLE 2-7

Estimates of Undiscovered Economically Recoverable Oil and Gas in the Gulf of Alaska

	Crude oil (billion barrels)	Natural gas (trillion cubic feet)
Gulf of Alaska OCS		
NPC (1972)	[1] 4	–
Silcox (proposed sale area only)	[2] 7-20	–
CEQ (after USGS)	[3] 3-6	[3] 15-30
CEQ (after Silcox)	[4] 6-25	–
Total Alaska OCS		
NPC	22	[5] 150
USGS (1974)	[6] 28-56	150-300

[1] The NPC estimate of 11.6 billion barrels of oil-in-place in the Gulf of Alaska was converted to ultimate production with a 33 percent recovery efficiency. National Petroleum Council, *U.S. Energy Outlook* (Washington: National Petroleum Council, 1972).

[2] Estimated by J.H. Silcox on the basis of a 60,000 cubic mile proposed lease sale area in the Gulf of Alaska. J.H. Silcox, testimony at the Hearing on Oil and Gas Development in the Atlantic and Gulf of Alaska OCS conducted by the Council on Environmental Quality, Anchorage, Alaska, Sept. 26, 1973.

[3] Using USGS estimates for oil and gas resources in the entire Alaska OCS, resources in the Gulf of Alaska OCS were estimated by weighting with the ratio of Pacific Margin Tertiary Province area to the total Alaska OCS area. U.S. Geological Survey, Department of the Interior, "U.S. Petroleum and Natural Gas Resources," March 1974.

[4] Using G. Gryc's estimates of the volume of the Pacific Margin Tertiary sediments (50,000 to 75,000 cubic miles) and Silcox's recovery ratios, an estimate of recoverable oil in the entire Pacific Margin Tertiary Province was made. National Petroleum Council, *Future Petroleum Provinces of the United States* (Washington: National Petroleum Council, 1970); Silcox, note 2 *supra*.

[5] The NPC estimate of 277.4 trillion cubic feet for Alaska was allocated to onshore and offshore using the onshore/offshore recoverable resources ratio in the USGS estimates.

[6] The USGS estimate includes both crude oil and natural gas liquids, so it may be 15 to 20 percent higher than the other estimates. U.S. Geological Survey, note 3, *supra*.

Methodology

The Atlantic and Gulf of Alaska OCS regions have been established as prospective oil and gas provinces. Because exploratory drilling has not yet been conducted,* no one knows whether commercial quantities are present there. Both areas have been subjected to extensive private geophysical reconnaissance which has confirmed the presence of thick sediment deposits as well as favorable geologic structures. The U.S. Geological Survey has purchased some of these data, but because of contractual provisions, neither the data nor analytical results derived from them may be released publicly.

Using such data, the Industry and USGS can differentiate between more and less attractive prospects for oil and gas exploration. Sophisticated digital processing techniques–bright spot processing–have recently been developed which provide more positive indication of the presence of significant amounts of hydrocarbons in subsurface formations. [27] However, it is still not possible to pinpoint future fields without exploratory drilling.

In consultation with the Geological Survey and other Federal agencies, CEQ developed a methodology to locate hypothetical potential oil and gas accumulations. First, because the seismic data purchased by USGS are proprietary, only publicly available data were used. Second, because the hypothetical areas did not need to be located precisely, they were identified by a circle with a 25–mile radius. Third, the circles were positioned to permit a wide geographical distribution of sites and to enclose a number of local areas which demonstrated enhanced potential for oil and gas accumulations at accessible water depths.

In general, the hypothetical resource areas encompass one or more locations where the geological formations exhibit irregularities as shown by changes in geophysical properties. The geophysical irregularities–or anomalies–were identified in published gravity, magnetic, and seismic data. Only irregularities in the proximity of thick sediments (10,000 feet or more) and underlying areas covered by water depths (600 feet or less) accessible with current technology were considered. A more detailed description of the methodology, as well as a bibliography listing the data sources used in the analysis, are given in Appendix F.

Hypothetical Locations

Hypothetical locations of potential oil and gas accumulations were developed in the three major sections of the Atlantic OCS and in the Gulf of Alaska. Four were developed in the Georges Bank Trough, five in the Baltimore Canyon Trough, and five in the Southeast Georgia Embayment (see Figure 2–1). For the Gulf of Alaska OCS, nine locations were developed, covering both sections of the Pacific Margin Tertiary Basin–the Gulf of Alaska Tertiary and the Kodiak Tertiary (see Figure 2–2).

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*Except for the one dry well drilled off Middleton Island in the Gulf of Alaska.

SUMMARY

Rapid expansion of exploration and production of oil and gas offshore is due both to improved capability to operate in deeper water and to the presence offshore of geologic formations favorable to accumulation of oil and gas.

Because of their favorable geology–thick, geologically young marine sediments–the Atlantic and Gulf of Alaska outer continental shelves have potential for future oil and gas development. Estimates of potential oil and gas resources in these OCS areas vary widely. Estimates of undiscovered economically recoverable crude oil and natural gas production from the Atlantic OCS range from 5 to 20 billion barrels and 35 to 110 trillion cubic feet, respectively. For the Gulf of Alaska OCS, estimates range from 3 to 25 billion barrels of oil; estimates of natural gas resources range from 15 to 30 trillion cubic feet.

Whether commercial quantities of oil and gas are present in either OCS region is not known. Using indirect geophysical techniques, all industry and the USGS can do is to locate areas geologically favorable to petroleum deposits. Exploratory drilling is required to confirm whether oil and gas are present.

Because hypothetical locations of potential oil and gas fields were needed for environmental and economic modeling, a methodology for developing approximate locations was devised. Geological data used were limited to those that were publicly available. Although proprietary seismic data would have provided more detail, development of approximate resource locations using publicly available data was adequate for purposes of modeling.

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15. "Comparison and Discussion of Some Estimates of United States Resources of Petroleum Liquids and Natural Gas," note 13 supra; V.E. McKelvey, note 13 supra; W.B. Rogers, et al., *Petroleum Exploration Offshore from New York,* Circular 46 (Albany: New York State Museum and Science Service, April 1973), pp. 9-16; L.K. Shultz and R.L. Grover, "Geology of the Georges Bank," *Amer. Assoc. Petroleum Geologists East Coast Offshore Symposium Technical Program,* Atlantic City, N.J., April 1973, pp. 2-8; R.E. Mattick, et al., "A Preliminary Report on U.S. Geological Survey Geophysical Studies of the Northeastern United States Outer Continental Shelf," U.S. Geological Survey Open File Report, Washington, D.C., 1973; J.P. Minard, et al., "Preliminary Report on the Geology Along the Atlantic Continental Margin of the

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Chapter 3. Perspectives on Energy Growth

U.S. energy consumption has been accelerating since 1950. Although part of this growth is due to increases in population, energy use per capita has been growing faster than population (see Table 3-1).

Consumption of energy is very much affected by a variety of factors, including the state of the economy and the business cycle. For example, the growth in energy consumption from 1970 to 1971 was only 1.9 percent. However, this small increase was strongly influenced by the slow rate of recovery from the 1969-1970 recession. The boom experienced in 1972 raised the rate of growth to 4.9 percent. (See Appendix G, Table 1.) Preliminary estimates for 1973 indicate a decline in the growth rate.

TABLE 3-1

U.S. Population and Energy Consumption Growth Rates[1]

Time period	Average population growth rate	Average per capita gross energy growth rate	Average total gross energy consumption growth rate
	Percent		
1950-1970	1.5	2.0	3.5
1960-1970	1.3	2.9	4.2
1965-1970	1.1	3.7	4.8
1971-1972	0.9	4.0	4.9

[1] Growth rates are calculated from the first and last years only.

Sources: Walter G. Dupree, Jr., "The National Energy Scene," Bureau of Mines, Department of the Interior, 1973; Walter G. Dupree, Jr. and James A. West, *United States Energy Through the Year 2000* (Washington: U.S. Government Printing Office, 1972).

HISTORICAL ENERGY MIX

The mix of energy supplies in the United States has changed considerably since World War II (see Table 3-2). In 1947, coal supplied almost one-half of the country's energy needs. Coal's share decreased to 38 percent by 1950 and is now less than 20 percent. Use of natural gas increased most sharply, doubling to 32 percent of the Nation's total energy consumption. Petroleum now supplies the largest portion (46 percent).

Until recently, foreign petroleum exporting nations increased their production each year, and the United States bought more from them because it was cheaper and domestic resources were limited. Many experts suggested that by 1985, the United States would depend on imports to satisfy over 50 percent of U.S. petroleum needs. It appears that U.S. energy consumption–based largely on imported oil–could keep growing at ever increasing rates. But recent

TABLE 3-2

U.S. Energy Mix of Primary Fuel Sources

	1947	1950	1960	1970	1972
	Percent				
Coal	47.9	38.0	22.6	19.3	17.2
Petroleum	34.6	39.7	45.1	43.9	45.5
Natural gas	13.6	18.2	28.5	32.6	32.3
Hydropower	3.9	4.1	3.8	3.9	4.2
Nuclear power	–	–	–	0.3	0.8

Source: Walter G. Dupree, Jr., "The National Energy Scene," Bureau of Mines, Department of the Interior, 1973.

events, including boycotts of foreign oil imports into the United States and wild price fluctuations for foreign crude oil, have shifted national efforts toward developing the capability for energy self-sufficiency. Further, it is clear that reducing the demand for scarce energy resources through energy conservation and efficient energy use is an essential component of self-sufficiency.

This chapter deals with energy supply and demand projections, both nationally and regionally. Regional projections were prepared in order to compare the role of oil and gas from the Atlantic and Gulf of Alaska outer continental shelves with that of other energy supplies.

NATIONAL ENERGY SUPPLY AND DEMAND FORECASTS

Energy supply and demand are forecast for the years 1985 and 2000.* Three levels of demand were prepared: a "high" rate of growth which assumes continuation of trends of the past few years, a "medium" growth case which reflects increases in fuel prices and public and private energy conservation measures and achieves a 10 percent reduction in energy demand by 1985 and a 15 percent reduction by 2000, and a "low" growth case which assumes conservation of energy and improvement of energy conversion efficiencies. It should be pointed out that the supply and demand assumptions upon which these forecasts are based were prepared prior to the current energy shortage and before the announcement of Project Independence. Thus, to the extent that Project Independence succeeds in reducing demand, shifting energy supply sources, and increasing domestic supply, the magnitude of the environmental effects presented in this study would change.

Energy demand in the transportation sector for the low growth case is reduced through greater reliance on mass transit, smaller cars, and nonhighway freight movements. Crude oil imports are reduced from a projected level of 21.7 million barrels per day in the year 2000 (as in the medium case) to 4.7 million barrels per day, coal production is vastly increased, and synthetic gas is produced by coal gasification.

In the low growth case domestic oil and gas production is assumed to have passed its peak, and neither offshore development nor more advanced recovery techniques can delay a dropoff in total

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*The high and medium supply and demand projections, prepared by the Department of the Interior, assume a population growth rate of 1 percent. The low projection, prepared by CEQ, assumes a 0.7 percent population growth rate.

TABLE 3-3

Projections of U.S. Energy Demands, by Sector[1]

[Quadrillion Btu's]

	1971 Actual	1985			2000		
		High	Medium	Low	High	Medium	Low
Household and commercial	14.3	19.0	17.4	18.0	21.9	18.7	20.4
Industrial	20.2	27.5	24.6	26.2	39.3	32.0	28.8
Transportation	17.0	27.1	25.3	18.8	42.6	37.2	20.6
Electric generation	17.4	40.4	36.6	21.2	80.4	72.8	51.2
Other[2]	–	2.6	2.2	–	7.7	5.0	–
Total	69.0	116.6	106.1	84.2	191.9	165.7	121.0

[1] The "high" case is the same as in Walter G. Dupree, Jr. and James A West, *United States Energy Through the Year 2000* (Washington: U.S. Government Printing Office, 1972). The "medium" case was prepared by the Department of the Interior for this study. The "low" case was prepared by the Council on Environmental Quality. Detailed forecasts, including the relevant assumptions for each forecast, appear in Appendices G and H. Population growth rates for the high and medium cases are assumed to be about midway between the D and E series estimated by the Bureau of the Census (about 1.0 percent per year). Series F (0.7 percent per year) was used for the low case. If the lower population growth rate were used with the high and medium demand cases, the total energy demand in the year 2000 would be reduced to roughly 176 quadrillion Btu's for the high case and 152 quadrillion Btu's for the medium case.

[2] Synthetic natural gas, which would be redistributed to household and commercial, industrial, and electric generation.

production. A conservative approach is also taken with growth in nuclear energy. The medium growth case assumes a quadrupling of nuclear energy between 1985 and 2000. The low growth case assumes its nearly tripling. This case also achieves a reduction in demand–about 20 percent by 1985 and 27 percent by 2000–relative to the medium growth case.

The three projections are presented by consuming sector in Table 3–3. The fuel resource requirements are shown in Table 3–4. Because the projections are ranked in order of their totals, individual components of the "low" case are not always the lowest figures of the three levels, the "high" figures are not always the highest, and the "medium" do not always fall between the two.

The forecasts for petroleum and gaseous fuels for the Nation as a whole are presented in Tables 3-5 and 3-6. The key to interpreting these tables is the role of supplemental supplies. They may be foreign imports, oil from the Atlantic and Gulf of Alaska outer continental shelves, or synthetic oil and gas from shale, coal, or other sources. In the medium demand scenario, over one-half of the total petroleum supply in 1985 and over two-thirds in 2000 are from sources other than oil and gas from the lower 48 states and the Alaskan North Slope.

Table 3-7 presents estimates of average levels of production that might be achieved in the Atlantic and Gulf of Alaska OCS (see Table 7-2). These estimates were used in the regional supply and demand scenarios. For example, New England's average oil production estimate for 1985 is 0.5 million barrels per day. If all three Atlantic coast areas could produce the average amount, the east coast could receive 1.5 million barrels of oil per day by 1985. The average oil production estimate for the Gulf of Alaska is 0.5 million barrels per day by 1985. These estimates will be used in subsequent analyses of energy supply alternatives.

REGIONAL BACKGROUND

The possible areas of production off New England, the Mid-Atlantic, and the South Atlantic have been considered independently in the supply and demand analysis and in the evaluation of alternative energy supplies. (See Table 3-8 for a summary of the energy resources and facilities located in each region and Table 3-9 for comparisons of regional energy, population, and land use statistics.)

New England depends on petroleum and natural gas to meet 93 percent of its energy needs. It has one small refinery of 10,000 barrels-per-day capacity but no indigenous production of petroleum, natural gas, and coal. New England's only contribution to primary energy production in 1971 was from 140 hydroelectric powerplants and three nuclear powerplants. Combined, these facilities satisfied only 5 percent of the area's primary energy needs.

TABLE 3-4

Projections of U.S. Energy Supply, by Source[1]

[Quadrillion Btu's]

	1971 Actual	1985			2000		
		High	Medium	Low	High	Medium	Low
Petroleum	30.5	50.7	47.4	28.0	71.4	62.5	25.4
Natural gas	22.7	28.4	25.9	25.5	34.0	28.3	20.0
Coal	12.6	21.5	16.8	18.5	31.4	19.8	33.4
Hydropower	2.8	4.3	4.3	3.4	5.9	5.9	4.2
Nuclear power	0.4	11.7	11.7	8.8	49.2	49.2	35.0
Geothermal	–	–	–	–	–	–	2.0
Solar	–	–	–	–	–	–	1.0
Total	69.0	116.6	106.1	84.2	191.9	165.7	121.0

[1] The "high" case is the same as in Walter G. Dupree, Jr. and James A West, *United States Energy Through the Year 2000* (Washington: U.S. Government Printing Office, 1972). The "medium" case was prepared by the Department of the Interior for this study. The "low" case was prepared by the Council on Environmental Quality. Detailed forecasts, including the relevant assumptions for each forecast, appear in Appendices G and H.

TABLE 3-5

Petroleum Supply Schedule, 1971 Actual, 1985 and 2000 Estimated[1]

[Million barrels per day]

	1971 Actual	1985			2000		
		High	Medium	Low	High	Medium	Low
Domestic supply							
Lower 48	11.3	9.2	9.2	8.5	6.0	6.0	7.3
Alaskan North Slope	–	2.0	2.0	–	3.5	3.5	–
Total domestic supply	11.3	11.2	11.2	8.5	9.5	9.5	7.3
Supplemental supplies required to meet demand[2]	[3]3.8	13.8	12.3	4.7	26.1	21.7	4.7
Total	15.1	25.0	23.5	13.2	35.6	31.2	12.0
Supplemental supplies as a percentage of total supplies	25	55	52	36	73	70	39

[1] The "high" case is the same as in Walter G. Dupree, Jr. and James A. West, *United States Energy Through the Year 2000* (Washington: U.S. Government Printing Office, 1972). The "medium" case was prepared by the Department of the Interior for this study. The "low" case was prepared by the Council on Environmental Quality. Detailed forecasts, including the relevant assumptions for each forecast, appear in Appendices G and H.

[2] May be foreign imports, synthetic oil from shale or coal, or oil from the Atlantic or Gulf of Alaska outer continental shelves.

[3] All imports.

TABLE 3-6

Gaseous Fuel Supply Schedule, 1971 Actual, 1985 and 2000 Estimated[1]

[Billion cubic feet per day]

	1971 Actual	1985			2000		
		High	Medium	Low	High	Medium	Low
Domestic supply–Lower 48 and Alaskan North Slope	57.9	59.8	59.8	59.8	60.7	60.7	45.2
Supplemental supplies required to meet demand[2]	[3]2.5	21.1	13.4	8.0	44.7	24.3	41.2
Total	60.4	80.9	73.2	67.8	105.4	85.0	86.5
Supplemental supplies as a percentage of total supplies	4	26	18	13	42	29	48

[1] The "high" case is the same as in Walter G. Dupree, Jr. and James A. West, *United States Energy Through the Year 2000* (Washington: U.S. Government Printing Office, 1972). The "medium" case was prepared by the Department of the Interior for this study. The "low" case was prepared by the Council on Environmental Quality. Detailed forecasts, including the relevant assumptions for each forecast, appear in Appendices G and H.

[2] May be foreign pipeline, synthetic gas from coal or petroleum feedstocks, or gas from the Atlantic or Gulf of Alaska outer continental shelves.

[3] All imports.

Coal and natural gas are more important to meeting the energy needs of the Mid-Atlantic, South Atlantic, and Pacific regions than of New England, although oil is still the largest contributor in all three. In the Middle and South Atlantic regions, coal supplies 21 and 26 percent of energy needs, respectively, petroleum products slightly more than 50 percent, and natural gas approximately 20 percent. As in New England, hydroelectric and nuclear power play only small roles in energy supply. Unlike New England, the other two Atlantic regions produce coal, oil, and natural gas. In addition, the east coast has approximately 12 percent of the total refining capacity in the United States—more than 1.6 million barrels per day. Most is located between Washington and New York.

Natural gas and hydroelectric power supply more energy to the Pacific than to the Atlantic region. Hydroelectric power accounts for about 20 percent of the gross energy inputs for the Pacific, natural gas about 34 percent, and petroleum products about 44 percent. The region also produces crude oil and natural gas and has about 16 percent of the Nation's refining capacity—2.2 million barrels per day.

REGIONAL ENERGY SUPPLY AND DEMAND FORECASTS

Oil and gas from the Atlantic OCS areas are projected to be brought ashore, refined, and used in the regions of production. Obviously, the regional impact of OCS production depends on estimates of the contribution of OCS resources to each region's total energy supply. The regional energy supply and demand forecasts include regional energy production and the energy that flows into and out of the region (see Tables 3-10 through 3-13 and Appendix G).

Even if all four OCS areas produced at their maximum estimated rates (as given in Chapter 7), a shortage of 9.3 million barrels per day of oil and 9.8 billion cubic feet per day of natural gas exists under the 1985 medium level national demand (see Tables 3–5 and 3–6). Under the low demand case, shortages

TABLE 3-7

Estimates[1] of Average Offshore Production

	1985	2000
Atlantic OCS[2]		
Oil (million barrels per day)	0.50	1.00
Gas (billion cubic feet per day)	0.60	2.70
Gulf of Alaska OCS		
Oil (million barrels per day)	0.50	1.50
Gas (billion cubic feet per day)	0.60	9.60

[1] Average of the high and low estimates as discussed in Chapter 7.

[2] All three Atlantic areas (the Georges Bank, the Baltimore Canyon, and the Southeast Georgia Embayment) are assumed to produce an equal share, totaling, e.g., 1.5 million barrels of oil per day and 1.8 billion cubic feet of gas per day in 1985.

Source: Resource Planning Associates, Inc., and David M. Dornbusch & Co., 1974, "Potential Onshore Effects of Oil and Gas Production on the Atlantic and Gulf of Alaska Outer Continental Shelf," prepared for the Council on Environmental Quality under contract No. EQ4AC002.

TABLE 3-8

Regional Energy Sources and Conversion Facilities, 1971

	Total United States	New England	Mid-Atlantic	South Atlantic	Pacific
Coal mines	5,576	–	1,189	1,775	8
Crude oil wells	515,890	–	35,660	13,573	40,781
Natural gas wells	119,251	–	17,186	21,154	1,002
Uranium mines	247	–	–	–	1
Petroleum refineries	247	1	19	9	43
Capacity (thousand barrels per day)	13,709	10	1,421	254	2,235
Natural gas processing plants	805	–	2	5	55
Capacity (million cubic feet per day)	75,134	–	8	1,255	1,999
Electrical production					
Fossil fuel					
Number of plants	2,363	137	214	259	135
Installed capacity (million kilowatts)	302,811	10,898	45,897	53,613	22,812
Nuclear					
Number of plants	19	3	7	1	3
Installed capacity (million kilowatts)	8,688	1,447	2,140	738	1,310
Hydropower					
Number of plants	1,176	140	131	129	285
Installed capacity (million kilowatts)	55,898	1,230	5,966	5,505	25,206

Source: Department of the Interior, *United States Energy Fact Sheets by States and Regions.*

would be cut to 1.7 million barrels per day and 4.4 billion cubic feet per day, respectively.

Regionally, production from the Atlantic OCS would reduce but not completely eliminate projected shortfalls on the east coast. Natural gas production from the Georges Bank could make New England a net regional exporter of gas by 2000. Of the four regions examined, however, only the Pacific could become self-sufficient in its projected requirements for petroleum, and it could do so only if about 60 per cent of the production from the Alaskan North Slope, or a combination of North Slope and Gulf of Alaska OCS crude oil, were dedicated to serve the region. For the other regions, additional energy supply components would have to supplement supplies from existing sources and the OCS.

ENERGY SUPPLY COMPONENTS

Many possible energy sources–near and long term–and many possible combinations are foreseeable. All the components of energy supply will be used in the total energy supply system, but some are restricted to specific areas. This section includes a discussion of some of the possible energy supply components for the Nation and for the Atlantic and Pacific coastal regions. It is by no means exhaustive. Rather, in order to provide an overview of the total-energy picture, the section briefly summarizes each supply component.

Importation of Crude Oil and Refined Products

In 1972, the most recent year for which complete

TABLE 3-9

Regional Energy, Population, and Land Area Statistics, 1971

	Total United States	New England	Mid-Atlantic	South Atlantic	Pacific
Energy consumption by end use, percent					
Household and commercial	21	41	32	17	18
Industrial	29	9	21	20	17
Transportation	25	25	23	29	32
Electric power	25	25	24	34	33
Energy supply by fuel type, percent					
Coal	18.2	2.1	21.0	26.4	1.4
Petroleum	44.1	83.5	55.5	51.6	43.6
Natural gas	33.0	9.4	19.6	19.6	34.2
Hydro	4.1	1.5	2.7	2.1	19.9
Nuclear	0.6	3.5	1.2	0.3	0.9
Other regional characteristics					
Population	206,255,000	12,022,000	37,570,000	31,243,000	25,932,000
Percentage of total U.S. population	100	6	18	15	13
Land area, square miles	3,615,122	66,608	102,745	278,776	916,728
Percentage of total U.S. land area	100	1.8	2.8	7.7	25.4
Population density, people per square mile	57.1	180.5	365.7	112.1	29.4
Total gross energy inputs, quadrillion Btu's	68.989	2.815	9.707	8.086	7.467
Percentage of total U.S. energy inputs	100	4	14	12	11
Energy consumption, Btu per capita					
Gross	333	234	258	259	277
Net	276	195	217	200	216

Sources: Department of the Interior, 1971, *United States Energy Fact Sheets by States and Regions;* Bureau of the Census, *Statistical Abstract of the United States: 1971* (Washington: Government Printing Office, 1971).

statistics are available, the United States imported 4.75 million barrels of crude oil and petroleum products per day (see Table 3-14).

Crude oil was shipped from 22 countries and petroleum products from 37 more. More than two-thirds of all imports came from the Western Hemisphere. About one-sixth of the imports came from North Africa and the Middle East, the remaining one-sixth from other Eastern Hemisphere countries.

The outlook for substantial increases in petroleum imports from the Western Hemisphere is not encouraging. The National Petroleum Council reports that Canadian and Latin American crude cannot fully meet the projected increase in U.S. oil import requirements. [1] Western Hemisphere nations, however, will probably continue to be an important

TABLE 3-10

New England Energy Supply and Demand, 1971 Actual, 1985 and 2000 Estimated[1]

[Trillion Btu's]

	1971	1985	2000
Demand			
Coal	59	–	–
Oil, including natural gas liquids	2,351	3,579	4,239
Gas, dry	264	320	337
Nuclear	98	966	3,265
Hydropower	44	49	65
Total regional demand	2,816	4,914	7,906
Supply			
Indigenous production			
Coal	–	–	–
Oil, including natural gas liquids			
Onshore	–	–	–
Georges Bank area of Atlantic OCS[2]	–	1,056	2,078
Gas, dry			
Onshore	–	–	–
Georges Bank area of Atlantic OCS[2]	–	226	1,018
Nuclear	98	966	3,265
Hydropower	44	49	65
Total indigenous production	142	2,297	6,426
Net energy inflows			
Coal	59	–	–
Oil, including natural gas liquids			
Domestic	1,547	1,665	1,426
Foreign	804	858	735
Gas, dry	264	94	(681)
Nuclear	–	–	–
Hydropower	–	–	–
Total net energy inflows	2,674	2,617	1,480
Total regional supply	2,816	4,914	7,906

( ) = outflows.

[1] The New England region consists of Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, and Connecticut.

The regional supply forecast is based on the medium national energy supply forecast (see Table 3-4).

[2] Based on Table 3-7.

Source: Walter G. Dupree, Jr., "The National Energy Scene," Bureau of Mines, Department of the Interior, 1973.

TABLE 3-11

Middle Atlantic Energy Supply and Demand, 1971 Actual, 1985 and 2000 Estimated[1]

[Trillion Btu's]

	1971	1985	2000
Demand			
Coal	2,040	1,932	1,867
Oil, including natural gas liquids	5,389	8,041	10,202
Gas, dry	1,903	2,281	2,499
Nuclear	113	1,870	7,227
Hydropower	262	368	437
Total regional demand	9,707	14,492	22,232
Supply			
Indigenous production			
Coal	1,996	2,100	2,300
Oil, including natural gas liquids			
Onshore	28	30	30
Baltimore Canyon area of Atlantic OCS[2]	–	1,056	2,078
Gas, dry			
Onshore	81	80	80
Baltimore Canyon area of Atlantic OCS[2]	–	226	1,018
Nuclear	113	1,870	7,227
Hydropower	262	368	437
Total indigenous production	2,480	5,730	13,170
Net energy inflows			
Coal	44	(168)	(433)
Oil, including natural gas liquids			
Domestic	3,471	3,130	2,914
Foreign	1,890	3,825	5,180
Gas, dry	1,822	1,975	1,401
Nuclear	–	–	–
Hydropower	–	–	–
Total net energy inflows	7,227	8,762	9,062
Total regional supply	9,707	14,492	22,232

( ) = outflows.

[1] The Middle Atlantic region consists of New York, New Jersey, and Pennsylvania.

The regional supply forecast is based on the medium national energy supply forecast (see Table 3-4).

[2] Based on Table 3-7.

Source: Walter G. Dupree, Jr., "The National Energy Scene," Bureau of Mines, Department of the Interior, 1973.

component of U.S. foreign crude oil imports.

The outlook for unlimited petroleum imports from the Eastern Hemisphere is even less encouraging. The oil embargo begun in October 1973 underscores the insecurity of these sources of foreign crude oil. Furthermore, without an embargo, the United States will be competing in the world crude oil markets with the other industrialized nations of Western Europe and with Japan as well as with the developing countries.

If large volumes of foreign crude oil are available for importation into the United States, the construction of one or more deepwater oil ports on the U.S. east and Gulf coasts is likely. With proper siting and operation of deepwater ports far offshore, importing oil by large tankers could be environmentally safer than importing oil by smaller tankers into congested inshore harbors. Depending on the level of imports at any given location, the onshore or secondary effects of

TABLE 3-12

South Atlantic Energy Supply and Demand, 1971 Actual, 1985 and 2000 Estimated[1]

[Trillion Btu's]

	1971	1985	2000
Demand			
Coal	2,139	2,887	2,758
Oil, including natural gas liquids	4,175	6,960	9,254
Gaseous fuels	1,581	1,760	1,992
Nuclear	26	2,713	10,459
Hydropower	166	234	298
Total regional demand	8,087	14,554	24,761
Supply			
Indigenous production			
Coal	3,667	4,400	4,800
Oil, including natural gas liquids			
Onshore	68	70	80
Southeast Georgia Embayment area of Atlantic OCS[2]	–	1,056	2,078
Gas, dry			
Onshore	234	240	250
Southeast Georgia Embayment area of Atlantic OCS[2]	–	226	1,018
Nuclear	26	2,713	10,459
Hydropower	166	234	298
Total indigenous production	4,161	8,939	18,983
Net energy inflows			
Coal	(1,528)	(1,513)	(2,042)
Oil, including natural gas liquids	–	–	–
Domestic	3,261	4,609	5,606
Foreign	846	1,225	1,490
Gas, dry	1,347	1,294	724
Nuclear	–	–	–
Hydropower	–	–	–
Total net energy inflows	3,926	5,615	5,778
Total regional supply	8,087	14,554	24,761

( ) = outflows.

[1] The South Atlantic region consists of Delaware, Maryland, the District of Columbia, Virginia, West Virginia, North Carolina, South Carolina, Georgia, and Florida.

The regional supply forecast is based on tha medium national energy supply forecast (see Table 3-4).

[2] Based on Table 3-7.

Source: Walter G. Dupree, Jr., "Tha National Energy Scene," Bureau of Mines, Department of the Interior, 1973.

deepwater port development are likely to be quite similar to those projected for development of resources on the OCS. [2]

Importation of Natural Gas

Although on balance the United States is a net exporter of natural gas to Mexico (see Table 3-15), it now imports natural gas by pipeline from both Canada and Mexico. Our southern neighbor will use its small amount of proven gas reserves in its own development and is not likely to export significant amounts to the United States. Although Canada has larger gas reserves,

TABLE 3-13

Pacific Energy Supply and Demand, 1971 Actual, 1985 and 2000 Estimated[1]

[Trillion Btu's]

	1971	1985	2000
Demand			
Coal	104	77	82
Oil, including natural gas liquids	3,259	5,209	7,442
Gas, dry	2,551	3,074	3,270
Nuclear	65	1,493	5,669
Hydropower	1,488	1,769	2,344
Total regional demand	7,467	11,622	18,807
Supply			
Indigenous production			
Coal	45	50	55
Oil, includes natural gas liquids			
Lower 48	2,583	2,600	2,700
Alaskan North slope[2]	–	4,230	8,460
Gulf of Alaska OCS	–	1,060	3,175
Gas, dry:			
Lower 48	728	800	850
Alaskan North Slope[3]	–	–	–
Gulf of Alaska OCS[2]	–	226	1,808
Nuclear	65	1,493	5,669
Hydropower	1,488	1,769	2,344
Total indigenous production	4,909	12,228	25,061
Net energy inflows			
Coal	59	27	27
Oil, including natural gas liquids			
Domestic	360	(2,681)	(6,893)
Foreign	316	–	–
Gas, dry	1,823	2,048	612
Nuclear	–	–	–
Hydropower	–	–	–
Total net energy inflows	2,558	(606)	(6,254)
Total regional supply	7,467	11,622	18,807

( ) = outflows.

[1] The Pacific region consists of Washington, Oregon, California, Alaska, and Hawaii. The regional supply forecast is based on the medium national energy supply forecast (see Table 3-4).

[2] Based on Table 3-7.

[3] North Slope gas was not considered because it is not known whether the gas will flow to the Midwest through a pipeline or to Valdez, Alaska, via pipeline for liquefaction and further transportation to the west coast.

Source: Walter G. Dupree, Jr., "The National Energy Scene," Bureau of Mines, Department of the Interior, 1973.

recent actions by the Canadian National Energy Board indicate that increases in natural gas exports may also be limited. Thus, imports of natural gas in liquefied form (LNG) from the Eastern Hemisphere and Alaska

TABLE 3-14

U.S. Sources of Crude Oil and Refined Products, 1972

	Million barrels per day	Percentage of total	Percentage of domestic production	Percentage of imports
Domestic production				
Onshore	7.80	54.9	82.4	
Offshore	1.67	11.7	17.6	
Total U.S. production	9.47	66.6	100.0	
Imports—crude and products				
Canada	1.11	7.8		23.4
Venezuela	0.96	6.7		20.2
Other Western Hemisphere	1.33	9.4		28.0
Total Western Hemisphere	3.40	23.9		71.6
Middle East	0.47	3.3		9.9
North Africa	0.23	1.6		4.8
West Africa	0.27	1.9		5.7
Other Eastern Hemisphere	0.38	2.7		8.0
Total Eastern Hemisphere	1.35	9.5		28.4
Total Imports	4.75	33.4		100.0
Total	14.22	100		

Source: Bureau of Mines, Department of Interior, 1973, *Mineral Industry Surveys, Petroleum Statement, Annual 1972* (Washington: Department of the Interior).

TABLE 3-15

Natural Gas Statistics, 1972

[Billion cubic feet]

Net marketed U.S. production	22,532.0
Imports (pipeline)	
Canada	1,009.0
Mexico	8.0
Imported LNG	0.002
Exports (pipeline)	
Canada	16.0
Mexico	15.0
Exported LNG (Alaska to Japan)	48.0

Source: American Gas Association, *1972 Gas Facts* (Arlington, Va.: American Gas Association, 1973).

could be more important to future energy supplies. Industry has begun a number of LNG projects involving the importation of LNG from North Africa, Asia, and the U.S.S.R. in the last 2 years. Liquefying the natural gas produced in association with crude oil captures a resource that otherwise goes to waste in some foreign countries. Importing LNG from Africa or Asia, however, is considerably more expensive than producing it domestically. Marine transportation costs for LNG under long-term contract range from about $0.65-0.85 per thousand cubic feet [3]; delivered price estimates are as high as $1.50 per thousand cubic feet. The average cost of domestic natural gas was about $0.23 per thousand cubic feet in September 1973. Transportation by interstate gas pipeline adds, on the average, another $0.28 per thousand cubic feet. [4] On this basis, imported LNG could not compete economically with OCS-produced natural gas. Importation raises questions of security of supply and balance of payments effects. In addition, LNG imports also raise questions of safety. Little work has been done to quantify the relationship between safety and siting of LNG facilities and to define the relative risks of siting facilities near population centers.

Domestic Onshore Production of Oil and Gas

Crude oil production statistics for the United States suggest that domestic onshore production has peaked at just over 8 million barrels per day. Development of

Prudhoe Bay and other fields in Alaska, coupled with expanded exploration and development in the lower 48 states, is projected to maintain this level or at most to increase production by a small amount. [5] New onshore development is not expected to result in significant increases in total production.

Ultimate production from existing fields can be increased by applying secondary and tertiary recovery methods–recent estimates of the additional crude oil that could be made available from secondary and tertiary recovery range from 0.7 [6] to 1.2 [7] million barrels per day by 1985. Such incremental production would range from about 6 to 10 percent of the projected shortfall in 1985, assuming the medium level of demand (see Table 3-5).

Projections by the National Petroleum Council are even more optimistic. With "adequate incentives," the NPC estimated that by 1985, secondary and tertiary recovery processes might account for one-half the oil production in the lower 48 states. [8]

Tertiary recovery costs were recently estimated at $0.75 to $1.50 per barrel. [9] Recent domestic crude oil price increases make secondary and tertiary recovery more attractive; they should provide the "adequate incentives" referred to in the NPC report.

Domestic Offshore Production of Oil and Gas

Increased exploration is important in adding to proved reserves. During the last 3 years, 1.9 million acres has been leased in the Gulf of Mexico–more than 20 percent of the total 9.1 million acres leased in the Gulf since 1954. About 2 years is required to bring newly leased acreage in the Gulf of Mexico into production, assuming pipeline delivery systems nearby with available capacity. Production from the more recent leases, therefore, will not begin for at least another year. Current production is about 1 million barrels per day.

Production from the Atlantic and Gulf of Alaska OCS is not expected before 1980 (see Table 7-3). Assumed maximum rates for oil could relieve roughly one-quarter of the deficit in petroleum supplied in the 1985 medium demand case and almost two-thirds of the low demand case deficit. Environmental, economic, and technological aspects of Atlantic and Gulf of Alaska oil and gas are discussed throughout this study.

Increased Direct Use of Coal

Using more coal directly is an alternative for some petroleum uses, e.g., electric power generation. There is enough coal, the Nation's most abundant fossil fuel energy resource, to last hundreds of years.

In its extraction and end uses, coal presents a number of environmental problems. A recent report by the Council on Environmental Quality [10] comparing the environmental effects of coal-fired powerplants with those of oil, gas, and nuclear systems demonstrated quantitatively that with presently prevailing environmental controls, coal-fired powerplant systems are the least desirable from an environmental standpoint. Even with the addition of the most effective controls available today, air and water, solid wastes, and land use impacts are higher with coal-fired systems than with oil, gas, or nuclear systems. In addition, coal systems cause more occupational deaths and injuries than other systems, chiefly related to underground mining and rail transport.

Synthetic Oil and Gas from Coal and Shale

Synthetic oil and gas produced from coal and shale may be important components of the future energy supply mix. The Appalachian coal fields would likely provide coal for the production of synthetics to be consumed on the east coast. The west coast or the Midwest would probably consume oil produced from shale and synthetic fuels produced from western coal.

At this time, there is no large-scale commercial production of synthetic fuels in the United States. Several processes for producing synthetic natural gas from coal are at the pilot plant stage. Costs for production by the different processes are expected to vary. Estimates of the cost of producing SNG from coal at a planned facility in New Mexico are about $1.30 per thousand cubic feet. [11]

Estimates of costs and environmental effects of producing oil from shale in commercial size plants are based on engineering designs and pilot plant experience. The disposal of spent shale–the residue after oil extraction–could be a significant problem. In addition, large volumes of water are needed to process the shale, and land effects similar to those from strip mining coal are likely. Costs for commercially producing crude oil from shale were estimated at about $5 in constant 1970 dollars. [12] Today material, construction, and leasing costs would probably increase the price of shale oil to $8 to $10 per barrel, the current level for "new" or "uncontrolled"* conventional crude oil. Thus, rising

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*Exempt from price controls.

TABLE 3-16

Estimates of Potential Availability of Synthetic Oil and Gas

	1985	2000
Synthetic gas from coal[1] (billion cubic feet per day)	1-5.5	10-15
Synthetic oil from coal[2] (million barrels per day)	0.3	N/A
Synthetic oil from shale[3] (million barrels per day)	0.4-1.0	N/A

N/A = Not Available.

[1] Paper by Elburt F. Osborn, Director, Bureau of Mines, "Clean Synthetic Fluid Fuels from Coal: Some Prospects and Projections," presented at the annual meeting of the American Petroleum Institute Division of Production, Denver, April 9-11, 1973 (low estimate 1985); Walter G. Dupree, Jr., "The National Energy Scene," Bureau of Mines, Department of the Interior, 1973 (high estimate for 1985 and high end low estimates for 2000).

[2] K. Doig, Shell Oil Company, supporting data for testimony at the Hearing on Oil and Gas Development in the Atlantic and Gulf of Alaska OCS conducted by the Council on Environmental Quality, Washington, D.C., Sept. 12, 1973, "Socio-Economic Impact of East Coast Outer Continental Shelf Development on U.S. and PAD District 1."

[3] National Petroleum Council, *U.S. Energy Outlook—Oil Shale Availability* (Washington: National Petroleum Council, 1973) (low estimate); Department of the Interior, 1973, "Final Environmental Statement for the Prototype Oil Shale Leasing Program" (high estimate).

crude oil prices, in addition to the shortage of energy, provide incentives for the development of a synthetic fuels industry. An estimation of quantities of synthetics available by 1985 and 2000 is given in Table 3-16.

Increased Nuclear Capacity

Nuclear energy will play a growing role in the Nation's energy supply between now and the year 2000. By 1985, nuclear energy is expected to increase to about 30 percent of the total net electrical energy generated, and by 2000 almost 70 percent.*

For some uses of petroleum, there are no substitutes, for example, in the petrochemical industry. Electric energy, however, can be used in place of petroleum in heating and air conditioning.

It would take 67 to 80 additional nuclear plants of 1,000-megawatt capacity each to substitute for 1.5 million barrels of oil, the estimated average production level for the three Atlantic OCS areas in 1985 (see Table 3–7). This represents a 33 percent increase in nuclear capacity over that forecast for 1985.

Theoretically, the planning horizon between now and 1985 may be sufficiently long to allow for the necessary design, licensing, and construction. However, nuclear generating capacity is already forecast to grow at a significant rate between now and then. Finding additional environmentally acceptable sites with adequate cooling water may be a problem. Nuclear construction projects have been delayed because of labor and equipment difficulties, and future projects may experience similar delays. An additional 80 nuclear powerplants could severely strain the capacity of equipment manufacturers and construction companies.

Geothermal Energy

Geothermal energy from wells in the Geysers Valley in California currently supplies power equivalent to 25 percent of the electricity needs of the city of San Francisco. As a source of energy, however, geothermal energy is extremely localized. In the United States, geothermal resources appear to be primarily in California.

Although geothermal power is one of the cleaner sources of energy, it is not free of all environmental problems. Steam from the wells often contains hydrogen sulfide or other minerals which must be removed before the steam can be used. Installation of geothermal generating equipment creates a local noise problem, and some foreign geothermal generating plants are experiencing problems of subsidence because the condensed steam was not reinjected into the wells.

Besides generating electric power, geothermal energy can be used for space heating. In Reykjavik, the capital of Iceland, geothermal energy heats the entire city of 80,000 people. It is fortunate that the geothermal wells are near the city because, as a rule, geothermal energy must be used or converted to electricity within a few miles of the well or heat is lost. The distance limitation reduces the flexibility for uses other than electric power generation.

Solar Energy

Current systems for solar energy are of two general types: solar collectors, which absorb the solar radiation and transform it to heat, and solar cells, which transform solar radiation to electrical energy. Solar collectors have been used successfully on houses to provide space heating and hot water.

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*Based on the medium demand forecast.

Solar cells for electric energy generation are used only on a very small scale. With existing technology, it would take 1 square mile of solar cells to meet the electric power requirements of 15,000 homes in the Washington, D.C., area. A 1,000-megawatt powerplant using solar energy could require more than 35 square miles of solar cells. For both technical and economic reasons, most experts view solar energy as a potential substitute for conventional forms in the long term. It is not expected to contribute significantly as an alternative to oil and gas from Atlantic and Alaskan OCS within the next 2 or 3 decades.

Tidal Power

This form of hydroelectric energy derives from the alternate filling and emptying of a bay or estuary that can be enclosed by a dam. One 250-megawatt tidal generating station is in operation in France, and a 1,000-megawatt generating station is in operation in Russia. High tides, such as those in the northeast United States and in Alaska, are required. It has been estimated that tidal power could supply 2 percent of New England's electrical energy requirements.

ENVIRONMENTAL IMPACTS OF ENERGY SUPPLY OPTIONS

The analysis of environmental impacts of energy supply options is based on an approach developed by CEQ [13] and extended under a recent contract study. [14] This approach quantifies environmental impacts at each step of the energy supply chain–from extraction and transportation of the primary resource through processing or conversion and end use. The impacts have been analyzed nationally and regionally. The regional analysis is particularly important here because OCS oil and gas development, increased use of coal, or exercise of any other energy options can cause significant regional environmental impacts. In the absence of data and analytical methods to measure the effects of emissions on air and water quality, emissions or residuals have been used as indicators of the relative desirability of energy supply systems.

Regional

New England was made the focus of the environmental impact analysis because it depends most heavily on petroleum and natural gas (93 percent of its gross energy inputs); it has virtually no indigenous energy resources and little refinery capacity; and the environmental damage caused by switching from oil and natural gas to another fuel, such as coal, would be greatest for New England.

CEQ developed five energy supply scenarios for New England and selected the following supply variables: OCS oil and gas from the Georges Bank, imported foreign oil, coal, and nuclear energy. The assumptions for the analysis are given in Table 3–17. In all cases coal makes up the shortfall resulting from insufficient oil and natural gas.

The base or reference case–Case A–is similar to the medium New England supply and demand forecast (see Table 3–10); the difference is that no OCS development was assumed and coal was used to make up the deficit. Case B is exactly the same as the medium projection and includes oil and gas production from the Georges Bank.

Case C also assumes no OCS or gas and oil imports were cut in half. Case D is similar to Case B, with imports cut in half. In Case E, oil imports and OCS oil and gas are one-half the level of Case B, and nuclear capacity for 2000 is estimated at 71 percent of the other case levels, which reflects a slower growth rate between 1985 and 2000.

In the analysis energy and end use patterns were kept constant to the maximum extent possible. A supply deficit of natural gas for heating homes and offices was made up with synthetic gas, such as produced by coal gasification. Similarly, an oil deficit was made up by coal liquefaction in 2000 to provide liquid products. Some end uses were changed in 1985 because the supply of synthetic gas from coal would not have grown rapidly enough to meet the full demand. The changes would be in the commercial sector, where direct burning of coal would replace some natural gas.

When coal was burned directly, environmental control technology in the form of stack gas cleanup was assumed available. Details concerning the assumptions for the scenarios are contained in Appendix I.

Cases B and C provide the greatest contrast in environmental effects. These two cases were also evaluated for the Middle and South Atlantic regions. (See Tables 3-18 and 3-19 for assumptions.)

The results for the three regions are shown in Tables 3-20, 3-21, and 3-22 and for New England are plotted in Figure 3-1.

For each environmental residual analyzed, the data

TABLE 3-17

New England Scenarios for Environmental Analysis

[Trillion Btu's]

Resource	1985					2000				
	Case number									
	A Base case, no OCS	B[1] Medium forecast with Atlantic OCS	C Reduced imports, no OCS	D Reduced imports with Atlantic OCS	E Reduced imports, reduced Atlantic OCS	A Base case, no OCS	B[1] Medium forecast with Atlantic OCS	C Reduced imports, no OCS	D Reduced imports with Atlantic OCS	E Reduced imports, reduced Atlantic OCS
Oil										
OCS	–	1,056	–	1,065	528	–	2,076	–	2,078	1,039
Domestic	1,665	1,665	1,665	1,665	1,665	745	1,426	745	1,426	917
Foreign	858	858	429	429	429	735	735	368	368	368
Total	2,523	3,579	2,094	3,150	2,622	1,480	4,239	1,113	3,872	2,324
Gas										
OCS	–	266	–	266	113	–	1,018	–	1,018	509
Domestic and imports	94	94	94	94	94	–	[2]681	–	[2]681	[2]172
Total	94	320	94	320	207	–	337	–	337	337
Coal[3]	1,282	–	1,711	429	1,070	3,096	–	3,463	367	2,848
Nuclear	966	966	966	966	966	3,265	3,265	3,265	3,265	2,332
Hydropower	49	49	49	49	49	65	65	65	65	65
Total	4,914	4,914	4,914	4,914	4,914	7,906	7,906	7,906	7,906	7,906

[1] The New England regional forecast (see Table 3-10).

[2] Exported from the New England region.

[3] Includes coal used for production of synthetic natural gas.

show the actual level in 1971 and the levels projected for 1985 and 2000. In Figure 3-1 the cases have been arranged so that moving from left to right the amount of coal used increases and the amount of oil used decreases.

In general, hydrocarbon emissions increase as the total oil supplied to a region increases. Particulates and carbon monoxide emissions, on the other hand, increase with use of more coal.

In New England, for example, substitute Case C, a low oil supply case, for Case B, a high oil supply case. About 195,000 tons of coal per day is required in 1985 to replace the oil and gas. This 40 percent decrease in petroleum products for New England, with the attendant increase in coal consumption, causes a 60 percent decrease in hydrocarbon emissions to the air, a more than 1,200 percent increase in particulate emissions, and a 300 percent carbon monoxide emissions increase. Organic water pollutants* decrease about 30 percent, but both suspended solids and total dissolved solids increase about 80 percent as a result of increased coal usage. Solid wastes increase about 50 percent and land disturbed increases about 40 percent.

Land, obviously, is disturbed by mining. Land is also disturbed by disposal of solid wastes created by coal combustion, gasification, and liquefaction and by pollution control equipment. Because the coal for New England would probably come from Appalachia, the land disturbance would be there rather than in New England. Further, if coal is gasified at the mine and the resulting gas piped to New England, the air pollution

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*The organic component of water polluted by production and distribution of OCS oil and gas was calculated using mean spill rates supplied by M.I.T. [15] Because mean spill rates have very high variances, the amount spilled in any year can be very much higher or lower than the mean spill rate.

TABLE 3-18

Middle Atlantic Scenarios for Environmental Analysis
[Trillion Btu's]

Resource	1985		2000	
	Case number			
	B[1] Medium forecast with Atlantic OCS	C Reduced imports, no OCS	B[1] Medium forecast with Atlantic OCS	C Reduced imports, no OCS
Oil				
OCS	1,056	–	2,078	–
Domestic	3,130	3,130	2,914	2,914
Foreign	3,825	1,913	5,180	2,590
Indigenous	30	30	30	30
Total	8,041	5,073	10,202	5,534
Gas				
OCS	226	–	1,018	–
Domestic and foreign	1,975	1,975	1,401	1,401
Indigenous	80	80	80	80
Total	2,281	2,055	2,499	1,481
Coal[2]	1,932	5,126	1,867	7,553
Nuclear	1,870	1,870	7,227	7,227
Hydropower	368	368	437	437
Total	14,492	14,492	22,232	22,232

[1] The Middle Atlantic regional forecast (see Table 3-11).

[2] Includes coal used for production of synthetic natural gas.

and solid waste impacts too would be felt in Appalachia rather than in New England.

Sulfur oxide emissions show no particular trend because of two assumptions: any direct coal combustion will be controlled by stack gas cleaning, and much of the sulfur is removed in coal gasification or liquefaction to produce a clean burning fuel.

All the cases can be estimated for the Middle and South Atlantic regions by interpolating between the two extremes (B and C) for those regions. The Middle Atlantic region is not so heavily dependent on oil and gas as New England, and the South Atlantic region is even less so.

National

For the national environmental effects, the medium energy supply forecast was used as the base and six energy supply scenarios were developed (see Table 3-23). The first five are analogous to Cases A through E, except that OCS oil and gas development is assumed for all three Atlantic OCS areas rather than just for the Georges Bank. All the scenarios were examined with both low- and high-level environmental controls on energy facilities.

The results for the national analysis are shown in Table 3-24, which is organized so that the amount of coal used increases and the amount of oil used decreases as one moves from top to bottom. Both the low and high levels of environmental control are shown.

Only solid wastes show a strong national trend from substitution of coal for assumed volumes of OCS oil and gas. As the amount of coal used increases, solid wastes increase. Particulate emissions show the same trend, but with a smaller difference between the extremes, Cases 2 and 3 (see Table 3-24). There are also striking differences between solid wastes generated in a scenario with a low level of environmental control and the same scenario with a high level of control.

TABLE 3-19

South Atlantic Scenarios for Environmental Analysis
[Trillion Btu's]

Resource	1985		2000	
	Case number			
	B[1] Medium forecast with Atlantic OCS	C Reduced imports, no OCS	B[1] Medium forecast with Atlantic OCS	C Reduced imports, no OCS
Oil				
OCS	1,056	–	2,078	–
Domestic	4,906	4,906	5,606	5,606
Foreign	1,225	613	1,490	745
Indigenous	70	70	80	80
Total	6,960	5,292	9,254	6,431
Gas				
OCS	226	–	1,018	–
Domestic and foreign	1,294	1,294	724	724
Indigenous	240	240	250	250
Total	1,760	1,534	1,992	974
Coal[2]	2,887	4,781	2,758	6,599
Nuclear	2,713	2,713	10,459	10,459
Hydropower	234	234	298	298
Total	14,554	14,554	24,761	24,761

[1] The South Atlantic regional forecast (see Table 3-12).
[2] Includes coal used for production of synthetic natural gas.

Although the substitution of coal for oil changed residuals in all cases, use of environmental control technology changed the level of environmental impacts by an amount equal to or greater than that resulting from substitution of coal for oil and gas.

It is important to note that for any given level of residuals in air, land, or water, the environmental effects will vary from region to region—and from locale to locale within a region. The effects of residuals will be determined by the local ambient residual levels and topographical and meteorological conditions.

No matter which alternative is chosen, significant environmental impacts result. Switching from dependence on oil and gas to dependence on coal simply switches the impact from one form or medium to another, as from hydrocarbons to particulate components of air emissions. All energy systems have environmental impacts. The only way to reduce these impacts is by conserving energy and by using environmental control technology.

SUMMARY AND CONCLUSIONS

Three scenarios for national energy supply and demand that correspond to three levels of growth in energy demand—high, medium, and low—are examined. For all three, existing domestic oil and gas sources will have to be supplemented by imports, synthetic oil and gas produced from shale and coal, and oil and gas produced in virgin areas.

Supplemental volumes would have to supply 52 percent of the total national petroleum demand and 18 percent of the gaseous fuel demand by 1985 under medium demand assumptions. Under the same assumptions, production from the three Atlantic OCS areas could account for 6 percent of the total national oil supply and 2 percent of the total national gas supply by 1985.

Atlantic OCS production is expected to contribute more to regional than national supplies. New England, the region most heavily dependent on oil and gas, may

TABLE 3-20

Environmental Impacts of New England Energy Supply Options

Case	Year	Air pollutants (thousand tons)							Water pollutants (thousand tons)										Solid waste (thousand tons)	Land utilized (thousand acres)
		Particulates	NO_x	SO_x	Hydrocarbons	CO	Other[1]	Total	Dissolved solids				Suspended solids	Organics	Other[3]	Total	BOD	COD		
									Acids	Bases	Other[2]	Total								
Base case (actual)	1971	87	349	347	347	35	25	1,192	0.2	0.2	63.6	64	1.8	23	29	118	1.1	7.0	5,223	638
Case B Medium forecast with Atlantic OCS	1985	48	501	448	435	24	106	1,562	–	–	99	99	2.0	31	290	422	2.0	12	37,172	1,088
Case D Reduced imports with Atlantic OCS	1985	240	509	451	437	35	106	1,777	–	–	1.3	155	6.5	27	290	479	2.0	12	48,642	1,218
Case E Reduced imports, reduced Atlantic OCS	1985	495	429	351	301	42	114	1,732	–	4.9	270	275	9.6	25	290	600	1.6	9.9	60,894	1,518
Case A Base case, no OCS	1985	435	475	325	165	36	156	1,592	–	6.3	350	356	8.9	25	290	680	1.2	7.5	61,850	1,634
Case C Reduced imports, no OCS	1985	818	506	511	180	93	95	2,001	–	7.9	405	413	13	22	290	738	1.2	7.5	69,010	1,784
Case B Medium forecast with Atlantic OCS	2000	56	801	431	1,195	32	318	2,632	–	–	127	127	2.8	32	980	1,142	2.6	16	125,300	1,707
Case D Reduced imports with Atlantic OCS	2000	220	618	433	1,196	41	318	2,824	–	1.4	175	176	6.5	30	980	1,193	2.6	16	136,121	1,837
Case E Reduced imports, reduced Atlantic OCS	2000	923	802	390	622	64	225	3,026	–	22	1,206	1,227	19	20	699	1,965	1.4	8.8	153,300	3,328
Case A Base case, no OCS	2000	454	824	350	61	63	311	2,063	–	25	1,446	1,471	18	15	980	2,484	0.6	3.4	198,751	3,218
Case C Reduced imports, no OCS	2000	461	833	382	72	71	316	2,185	–	27	1,572	1,599	19	13	980	2,611	0.6	3.4	204,395	4,095

[1] Includes miscellaneous air pollutants such as aldehydes and the total air pollutants resulting from the nuclear supply chain that were not disaggregated.

[2] Includes miscellaneous dissolved solids.

[3] Includes water pollutants resulting from nuclear supply chain.

Sources: Council on Environmental Quality (1971). Hittman Associates, Inc., 1974, "Environmental Impacts of Alternatives to Outer Continental Shelf Oil and Gas Production," prepared for the Council on Environmental Quality under contract No. EQC308 (1985 and 2000).

TABLE 3-21

Environmental Impacts of Middle Atlantic Energy Supply Options

Case	Year	Air pollutants (thousand tons)							Water pollutants (thousand tons)										Solid waste (thousand tons)	Land utilized (thousand acres)
		Particulates	NO_x	SO_x	Hydrocarbons	CO	Other[1]	Total	Dissolved solids				Suspended solids	Organics	Other[3]	Total	BOD	COD		
									Acids	Bases	Other[2]	Total								
Base case (actual)	1971	1,048	1,303	936	2,191	180	42	5,700	–	8	396	403	24	21	34	483	3	16	40,334	2,661
Case B Medium fore-cast with Atlantic OCS	1985	1,026	1,514	1,007	2,595	114	200	6,456	–	8	423	431	25	38	561	1,056	3	19	108,648	3,420
Case C Reduced imports, no OCS	1985	2,227	1,612	1,588	2,379	344	182	8,332	–	22	920	942	52	26	561	1,581	2	14	168,062	4,660
Case B Medium fore cast with Atlantic OCS	2000	1,110	1,478	967	2,859	122	690	7,226	–	9	478	487	26	62	2,168	2,745	4	23	314,858	4,964
Case C Reduced imports, no OCS	2000	1,974	1,758	633	1,737	179	692	6,973	–	54	3,088	3,142	50	32	2,168	5,392	2	13	468,069	9,671

[1] Includes miscellaneous air pollutants such as aldehydes and the total air pollutants resulting from the nuclear supply chain that were not disaggregated.

[2] Includes miscellaneous dissolved solids.

[3] Includes water pollutants resulting from nuclear supply chain.

Sources: Council on Environmental Quality (1971); Hittman Associates, Inc., 1974, "Environmental Impacts of Alternatives to Outer Continental Shelf Oil and Gas Production," prepared for the Council on Environmental Quality under contract No. EOC308 (1985 and 2000).

TABLE 3-22

Environmental Impacts of South Atlantic Energy Supply Options

Case	Year	Air pollutants (thousand tons)							Water pollutants (thousand tons)										Solid waste (thousand tons)	Land utilized (thousand acres)
		Particulates	NO_x	SO_x	Hydrocarbons	CO	Other[1]	Total	Dissolved solids				Suspended solids	Organics	Other[3]	Total	BOD	COD		
									Acids	Bases	Other[2]	Total								
Base case (actual)	1971	1,670	1,389	921	1,824	184	30	6,018	–	5.5	305	311	5	17	7	340	3	15	30,242	3,242
Case B Medium fore-cast with Mid-Atlantic OCS	1985	2,024	2,187	1,526	2,091	215	284	8,327	–	7	430	437	8	31	814	1,290	4	26	147,752	5,296
Case C Reduced imports, reduced OCS	1985	2,675	2,172	1,415	1,819	268	274	8,713	–	13	536	549	8	20	814	1,391	3	21	177,144	5,989
Case B Medium fore-cast with Mid-Atlantic OCS	2000	2,197	2,297	1,593	2,401	241	996	9,725	–	7	524	531	9	41	3,138	3,719	6	35	442,733	7,865
Case C Reduced imports, reduced OCS	2000	3,238	2,018	1,028	1,254	296	982	8,816	–	19	1,382	1,401	14	24	3,138	4,577	4	26	498,052	10,455

[1] Includes miscellaneous air pollutants such as aldehydes and the total air pollutants resulting from the nuclear supply chain that were not disaggregated.

[2] Includes miscellaneous dissolved solids.

[3] Includes water pollutants resulting from nuclear supply chain.

Sources: Council on Environmental Quality (1971); Hittman Associates, Inc., 1974, "Environmental Impacts of Alternatives to Outer Continental Shelf Oil and Gas Production," prepared for the Council on Environmental Quality under contract No. EOC308 (1985 and 2000).

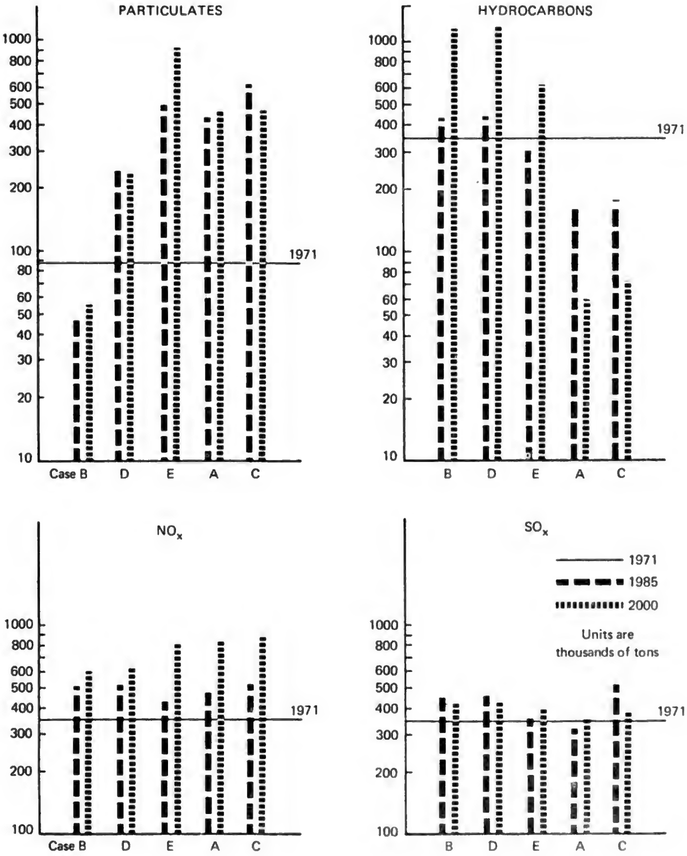


Figure 3-1. Environmental Impacts of New England Energy Supply Options

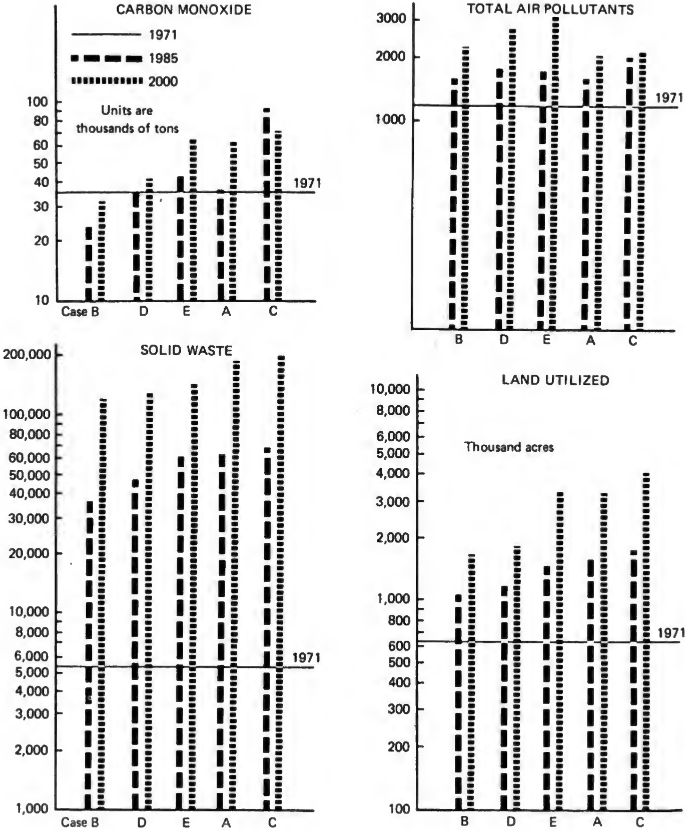
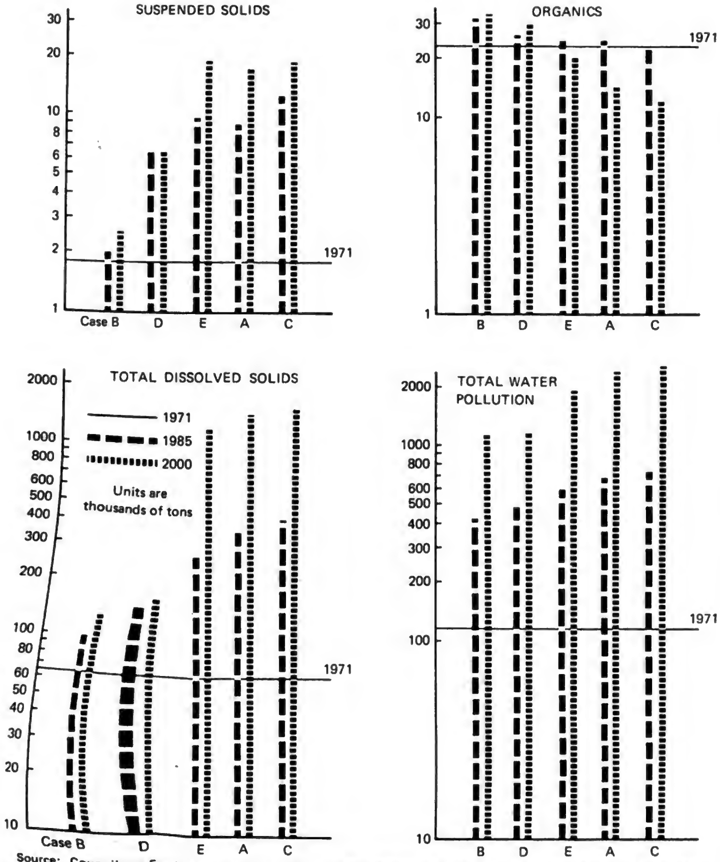


Figure 3-1 *—Continued*



Source: Council on Environmental Quality (1971); Hittman Associates, Inc., 1974, "Environmental Impacts of Alternatives to Outer Continental Shelf Oil and Gas Production," prepared under contract No. EQC308 (1985 and 2000).

Figure 3-1—*Continued*

TABLE 3-23

Total U.S. Energy Consumption, by Fuel

[Quadrillion Btu's]

Resource	1965						2000					
	Case number											
	1 Base case no OCS	2 Medium forecast with Atlantic OCS[1]	3 Reduced imports no OCS	4 Reduced imports with Atlantic OCS[1]	5 Reduced imports, reduced Atlantic OCS[1]	6 Reduced imports with Atlantic & Alaska OCS	1 Base case, no OCS	2 Medium forecast with Atlantic OCS[1]	3 Reduced imports no OCS	4 Reduced imports with Atlantic OCS[1]	5 Reduced imports reduced Atlantic OCS[1], reduced nuclear	6 Reduced imports with Atlantic[1] & Alaska OCS
Oil												
Domestic (lower 48 (plus North Slope)	22 600	22 600	22 600	22 600	22 600	22 600	19 210	19 210	19 210	19 210	19 210	19 210
Imported	20 594	20 594	10 297	10 297	10 297	10 297	34 997	34 997	17 499	17 499	17 499	17 499
Atlantic OCS	–	3 168	–	3 168	1 584	3 168	–	6 234	–	6 234	3.117	6 234
Gulf of Alaska OCS		–	–	–	–	1 060	–	–	–	–	–	3 175
Synthetic liquids	1 000	1 000	1 000	1 000	1 000	1 000	2 010	2 010	2.010	2 010	2 010	2 010
Total	44 194	47 362	33 897	37 065	35 481	38 125	56 217	62 451	38 719	44 953	41 836	48.128
Natural gas												
Domestic and others[2]	25 179	25 179	25 179	25 179	25 179	25.179	25 252	25 252	25 252	25 252	25.252	25 252
Atlantic OCS		678		678	339	678	–	3 054	–	3 054	1 527	3 054
Alaska OCS	–		–		–	226	–	–	–	–	–	1 808
Total	25 179	25 857	25 179	25 857	25 518	26 083	25 252	28 306	25 252	28 306	26 779	30 114
Coal	20 648	16 800	30 443	27 097	29 020	25 811	29 046	19 758	46 544	37 256	56 130	32 273
Hydropower	4 320	4 320	4 320	4 320	4 320	4 320	5 950	5 950	5 950	5.950	5 950	5 950
Nuclear power	11 750	11 750	11 750	11 750	11.750	11 750	49 230	49 230	49 230	49 230	35 000	49 230
Total	106 089	106 089	106 089	106 089	106 089	106 089	165 695	165 695	165 695	165 695	165 695	165 695

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[1] All three Atlantic OCS areas are assumed to produce at average production estimates (see Table 3-7).

[2] Not including synthetics.

TABLE 3-24

Environmental Impacts of National Energy Supply Options

Case Description[1]	Year	Level of environmental control	Water pollutants (million tons)		Air pollutants (million tons)					Solid waste (million tons)	Land utilized (million acres)
			Suspended solids	Total	SO_x	Particulates	Hydrocarbons	CO	Total		
Base case (actual)	1971		143	224	44	106	79	611	877	2,040	24
Case 2—Base case, no OCS	1985	Low	174	278	61	136	97	766	1,110	3,250	38
		High	170	275	30	97	88	744	996	936	35
Case 1—Medium forecast with Atlantic OCS[2]	1985	Low	174	280	61	143	96	765	1,120	3,860	36
		High	170	276	29	98	88	744	996	1,000	33
Case 6—Reduced imports with Atlantic[2] and Alaska OCS	1985	Low	161	262	67	153	92	715	1,080	4,660	39
		High	157	255	29	93	84	695	936	1,110	36
Case 4—Reduced imports with Atlantic OCS[2]	1985	Low	162	262	67	154	92	714	1,080	4,850	39
		High	157	255	28	94	84	695	936	1,110	36
Case 5—Reduced imports, reduced Atlantic OCS[2]	1985	Low	164	267	67	156	92	722	1,090	5,150	38
		High	159	258	29	96	84	704	946	1,130	36
Case 3—Reduced imports, no OCS	1985	Low	167	271	68	159	92	730	1,100	5,450	38
		High	161	262	30	98	85	713	957	1,140	35
Case 2—Base case, no OCS	2000	Low	225	373	68	164	123	1,020	1,440	5,440	51
		High	221	367	36	125	111	990	1,310	2,700	47
Case 1—Medium forecast with Atlantic OCS[2]	2000	Low	204	342	71	171	111	931	1,350	6,900	53
		High	199	333	34	117	101	909	1,210	2,850	48
Case 6—Reduced imports with Atlantic[2] and Alaska OCS	2000	Low	180	306	70	164	108	842	1,250	7,410	54
		High	174	295	32	105	98	819	1,100	2,890	50
Case 4—Reduced imports with Atlantic OCS[2]	2000	Low	175	301	73	172	104	823	1,240	8,180	54
		High	169	288	31	105	95	802	1,070	2,970	51
Case 5—Reduced imports, reduced Atlantic OCS[2]	2000	Low	189	322	107	241	105	858	1,400	10,500	65
		High	179	299	37	118	97	839	1,130	2,730	60
Case 3—Reduced imports, no OCS	2000	Low	203	346	56	162	107	912	1,290	9,630	48
		High	195	328	30	121	100	895	1,190	2,910	44

[1] Cases are vertically arranged in order of decreasing total oil supply and increasing coal supply.

[2] All three Atlantic OCS areas are assumed to produce at average production estimates (see Table 3-7).

Source: Computed by the Massachusetts Institute of Technology Energy Laboratory using environmental coefficients provided by Hittman Associates, Inc.

obtain 30 percent of its crude petroleum and 71 percent of its gas from Georges Bank by 1985, and by 2000 it could export some gas to other parts of the country.

Oil and gas from the Atlantic OCS will not be so important to energy supplies in the Middle and South Atlantic regions as in New England. Production from the Southeast Georgia Embayment may provide 15 percent of the South Atlantic region's oil requirements and 13 percent of its gas requirements by 1985. The Baltimore Canyon may provide 13 percent of the oil and 10 percent of the gaseous fuel requirements for the Mid-Atlantic by 1985.

Pacific coast requirements for additional oil can be met from the North Slope. Indications are that production from the Gulf of Alaska will exceed that region's needs.

In addition to OCS oil and gas production, energy will be supplied by increased coal production and in the longer term by geothermal energy, oil and gas from coal and shale, and solar energy. They are not in fact "alternatives" because several components will probably be required to provide the supplementary energy that will be needed. Energy conservation, however, can reduce both the number of components and the amount of energy required from each.

The onshore environmental effects (land disturbed and solid waste) of substituting coal are greater than those of using a combination of imported and foreign oil. Further, these effects may well take place outside the energy-consuming region, centering in the region that supplies the coal. Other environmental impacts associated with using more coal–such as increased water pollution–may also center in the supplying region rather than the consuming region. Location of coal conversion facilities in the mining areas will further increase these environmental impacts.

Monitoring changes in the mix of energy supplies is important at the local level, for the environmental damages are more pronounced locally than regionally or nationally.

Nationally, the most noticeable impact of substituting coal for oil is the generation of increased amounts of solid waste. Total air pollutants, water pollutants, and land disturbed show no definite patterns. However, use of environmental control technology has the potential for reducing forecast environmental impact levels.

Demanding less energy–by energy conservation and increased energy conversion and utilization efficiency–is a very important way to cut projected increases in environmental damages. Although control technology can help, it cannot eliminate damages as effectively as using less energy can. Energy demand reduction in the United States will also ease the world energy supply situation.

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13. Council on Environmental Quality, note 10 supra.
14. Hittman Associates, Inc., 1973, "Environmental Impacts, Efficiency, and Cost of Energy Supply and End Use," prepared for the Council on Environmental Quality under contract No. EQC308, HIT-561.

15. Massachusetts Institute of Technology, "Analysis of Oil Spill Statistics," Sec. II of *Primary, Physical Impacts of Offshore Petroleum Developments,* prepared for the Council on Environmental Quality under contract No. EQC330 (Cambridge: Massachusetts Institute of Technology, 1974), Report No. MITSG 74-20.

Chapter 4. Technology for Developing Oil and Gas Resources Offshore

Technology for locating and exploiting oil and natural gas offshore has been evolving since the first offshore platform was constructed in shallow water near Santa Barbara in 1897. The first platform beyond sight of land was completed in 1947 off Louisiana. Since the first oil and gas leases in the Gulf of Mexico OCS nearly 20 years ago, offshore facilities have operated in increasingly more hostile environments.

By the end of 1972, over 17,000 wells had been drilled offshore (see Table 4-1). In state waters alone, nearly 7,000 wells were drilled, with 2,499 off California, 1,631 in the Gulf of Mexico, and 193 in Cook Inlet. In Federal waters, 10,249 wells were drilled in this period, with 10,152 off Louisiana.

DEVELOPMENT OF OCS OIL AND GAS RESOURCES

Development on the outer continental shelf involves a number of steps: (1) geophysical exploration, (2) exploratory drilling, (3) field development, (4) production, (5) transportation and storage, and (6) processing. This chapter describes these steps and then gives a brief overview of the accidents, oil spills, operational discharges, and other damage that can result from OCS oil and gas operations. The adequacy of the technologies and practices employed is examined in Chapter 8.

Geophysical Exploration

Geophysical exploration describes all the techniques, except drilling, used to locate geological formations which may contain oil and gas accumulations. It includes passive reconnaissance techniques such as air and shipborne measurements of the earth's magnetic and gravity fields and of hydrocarbon seeps into the atmosphere.

TABLE 4-1

U.S. Offshore Oil and Gas Wells, Through 1972[1]

	Oil	Gas	Dry	Total
Alaska				
State	193	17	75	285
Federal	–	–	–	–
California				
State	2,499	30	389	2,918
Federal OCS	198	1	76	275
Gulf of Mexico				
State	1,631	479	1,430	3,540
Federal OCS	4,509	1,790	3,853	10,152
Total				
State	4,323	526	1,894	6,743
Federal OCS	4,707	1,793	3,929	10,427
Total	9,030	2,319	5,823	17,170

[1] Includes both exploratory and development wells. The percentage of successful wells depends upon the type of well. A high percentage of development wells is successful because the presence of commercial quantities of oil and gas resource had been previously established. On the other hand, the success of exploratory wells is considerably lower, ranging from 14.6 to 17.6 percent since 1965. Drilling to discover new fields—wildcat exploration—is the least successful. Since 1965, the percentage of successful wildcat wells has varied from 8.5 to 11.1 percent.

Source: American Petroleum Institute Committee on Exploration, mimeographed materials, July 1, 1973.

Geophysical exploration also includes active surveying techniques such as seismic analysis, bottom sampling, and bottom coring. Seismic data are obtained by bouncing sound waves off the bottom to obtain a profile of subsurface formations. Propane-oxygen guns and high-powered oscillators rather than explosives generate the sound waves. Figure 4-1 illustrates a seismic surveying technique.

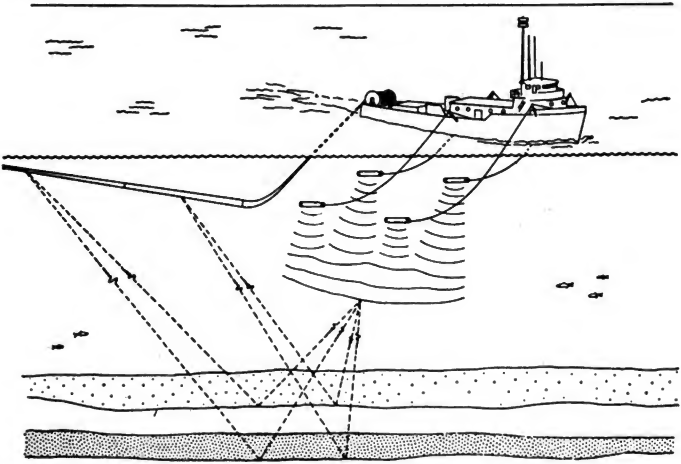
Bottom sampling and coring are used to obtain samples of the ocean floor and subsurface for geological examination. Coring, taking a core sample by drilling a shallow hole, is useful in identifying the type of unconsolidated sediments on the ocean bottom.

Exploratory Drilling

Exploratory drilling is required to determine whether commercial quantities of oil and gas are present. In order to drill into offshore formations, the drilling equipment is mounted on a platform–a barge, a drill ship, a semisubmersible, or a jackup. The two most widely used are jackups and semisubmersibles.

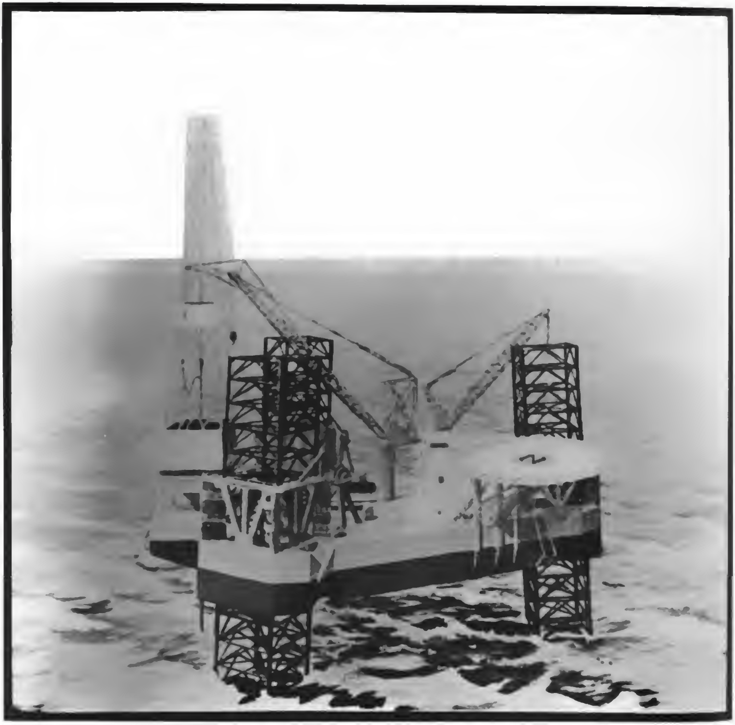
A jackup or self-elevating drilling platform (see Figure 4-2) has buoyant hulls so that the platform, drilling rig, drilling equipment, and supplies can be floated to the drilling site. When the platform reaches the site, the legs are jacked downward to the ocean floor and the platform deck is raised above the sea surface. A semisubmersible drilling platform (see Figure 4-3) is similar to a floating drilling rig and is supported by either displacement hulls or large caissons. Because many semisubmersible drilling units operate while afloat or anchored, they are used extensively for deepsea drilling.

Barges are frequently used for shallow water drilling. Drill ships, on the other hand, are often used to drill in waters deeper than 500 feet but probably are limited to less than 3,000 feet. They maintain their location with either anchors or dynamic positioning propellers to compensate for movement. Once the platform is positioned above the drill site, the drill stem is lowered to the ocean floor through a conductor



Source: Offshore Technology Conference, *1969 Offshore Technology Conference, May 18-21, Houston, Texas, Preprints* (Houston: Offshore Technology Conference, 1969).

Figure 4-1. Seismic Surveying

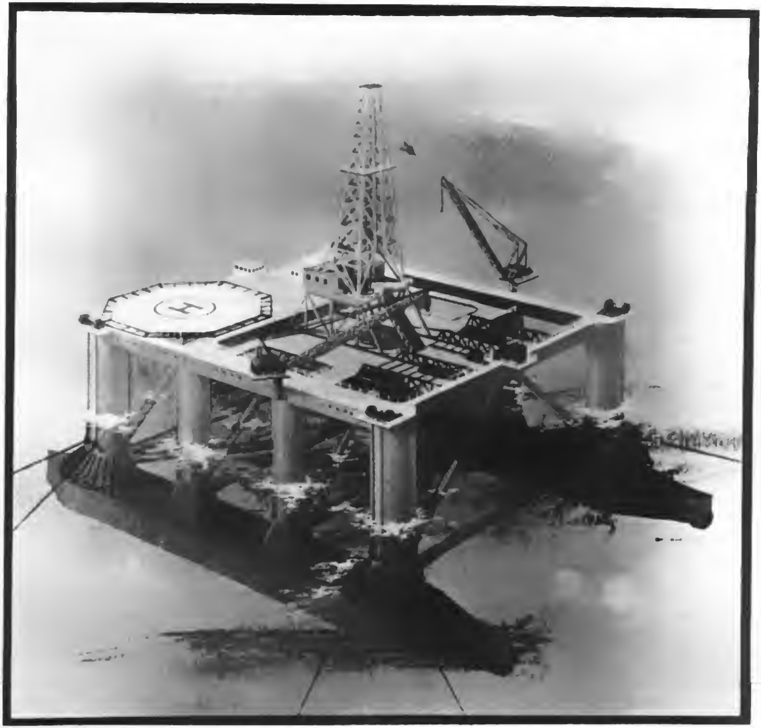


Source: Tetra Tech, Inc., 1973, "The Effect of Natural Phenomena on OCS Gas and Oil Development," prepared for the Council on Environmental Quality under contract No. EQ4AC010.

Figure 4-2. A Jackup or Self-Elevating Drilling Platform

pipe or a riser, depending on the type of platform used. Drilling methods and much of the equipment are identical to those used onshore.

Exploratory drilling is one of the most hazardous steps in developing offshore oil and gas. The potential hazard stems from the possibility of a blowout—the sudden surge of oil or gas pressure up the drill hole causing loss of control over the well. Although most blowouts involve only gas, large quantities of oil may be released to pollute the marine environment. If



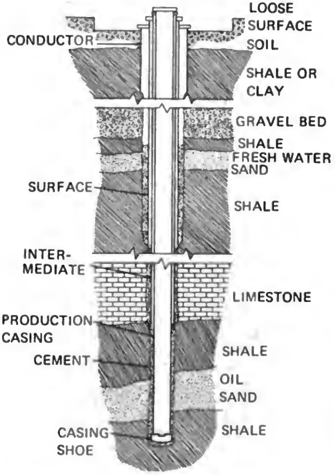
Source: Tetra Tech, Inc., 1973, "The Effect of Natural Phenomena on OCS Gas and Oil Development," prepared for the Council on Environmental Quality under contract No. EQ4AC010.

Figure 4-3. A Semisubmersible Drilling Platform

ignited, oil and gas may burn out of control, threatening personnel and equipment.

Drilling companies employ safeguards to minimize the likelihood of blowouts. These include circulating a heavy fluid called "drilling mud" in the drill hole to counteract the possible sudden flow of oil or gas, encasing the upper part of the drill hole with steel pipe set in cement to minimize the possiblity of a blowout around the outside of the drill, and installing blowout preventers–control valves capable of closing off the drill hole in case a blowout does begin.

The type of casing used depends on geological structure and the formation pressures encountered in drilling. A cross section of a typical geological structure and casing configuration required for safe operations is presented in Figure 4-4.



Source: Petroleum Extension Service, Division of Extension, University of Texas, *A Primer of Oil Well Drilling* (3d ed., Austin: Petroleum Extension Service, University of Texas, 1970).

Figure 4-4. Geological Structure and Casing in a Typical Oil Well

The casing provides an anchor to which the blowout preventer (BOP) stack is attached. The BOP stack is a series of control valves which can close part or all of the drill hole if there is a threat of losing control of the well (see Figure 4-5). Pipe rams close off the annular space between the casing and the drill pipe if oil or gas blows the drilling mud up the annulus. Blind rams close the entire drill hole when there is no drill pipe in the hole, and shear rams close the hole by shearing the drill pipe and dropping it into the well.

In addition to the potential threat of a blowout, there are other possible environmental damages associated with offshore drilling operations. Drill cuttings and drilling mud are usually disposed of in the ocean. Improper disposal of oil-contaminated and toxic materials (in violation of OCS orders) may damage biological life near the drilling platforms. Other liquid and solid materials may also be dumped overboard.

ield Development

Discovery of commercial quantities of oil or gas calls for development plans which consider additional exploratory wells to determine the extent and capacity of the field; selection, construction, and assembly of the production facility; number of production wells; and transportation of the oil or gas to a processing plant. These development plans for OCS and state leases are submitted to the responsible Federal and state authorities, respectively, for approval before development begins.

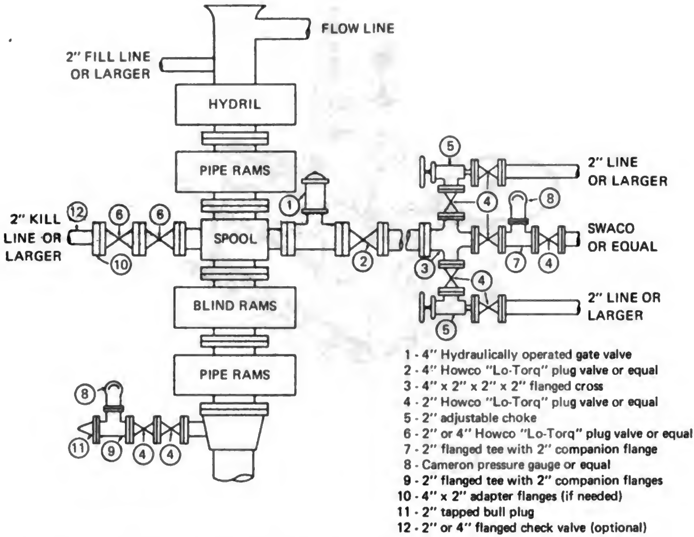
Field Development Facilities. An important choice is the facility for development drilling and production. In contrast to exploratory drilling, most offshore development drilling and production facilities are fixed platforms:

> Most offshore [production] platforms are comprised of a multi-level deck section supported by a framework or "jacket" of tubular steel members. Normally, the jacket is constructed onshore, barged to the installation site and launched. Steel piles are driven or drilled through the structure legs to hold the platform in position. Finally the deck section is installed to complete installation. [1]

A fixed platform is shown in Figure 4-6. Such a platform may be used to drill 20 to 30 wells. After all wells are drilled, the drilling rig is disassembled and production equipment is installed on the platform.

An emerging alternative to fixed production platforms is the subsea production system, which involves placing the wellheads on the ocean floor rather than on platforms. There are three types of subsea systems under development: single subsea wells, encapsulated systems, and nonencapsulated multiwell systems.

The single subsea well is drilled from a mobile rig and is then completed on the ocean floor. Oil and gas are piped to a nearby fixed platform or to a shore facility. Eighty-two of these systems are now active. [2] For the second type, dry chambers enclose



1 - 4" Hydraulically operated gate valve
2 - 4" Howco "Lo-Torq" plug valve or equal
3 - 4" x 2" x 2" x 2" flanged cross
4 - 2" Howco "Lo-Torq" plug valve or equal
5 - 2" adjustable choke
6 - 2" or 4" Howco "Lo-Torq" plug valve or equal
7 - 2" flanged tee with 2" companion flange
8 - Cameron pressure gauge or equal
9 - 2" flanged tee with 2" companion flanges
10 - 4" x 2" adapter flanges (if needed)
11 - 2" tapped bull plug
12 - 2" or 4" flanged check valve (optional)

Source: Tetra Tech, Inc., 1973, "The Effect of Natural Phenomena on OCS Gas and Oil Development," prepared for the Council on Environmental Quality under contract No. EQ4AC010.

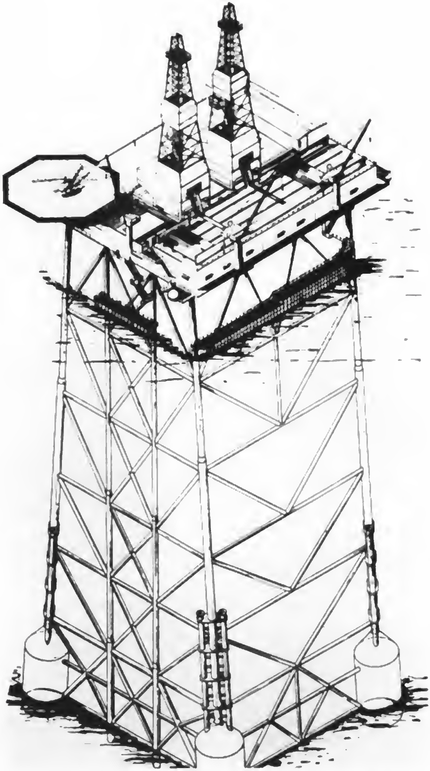
Figure 4-5. A Typical Blowout Preventer Arrangement

essentially dry land wellheads on the ocean floor. Workmen enter the 1-atmosphere (nominally 14.7-pound-per-square-inch pressure) chamber from a diving bell or submarine. Two systems–one developed by SEAL and the other by Lockheed and Shell–are now being tested. If "1-atmosphere encapsulated systems can be economically extended to 3000-foot depths," the cost of subsea completions will be relatively insensitive to water depth. [3] The third type involves a wet system of several clustered subsea wells drilled from a vessel positioned over the system. The production equipment is located within the system and is serviced by a diving bell (which does not require a professional diver). This system is under development by Exxon and will be tested in early 1974. It is shown in Figure 4-7.

Drilling and Well Completion. After the fixed platform or subsea system is assembled, development drilling, similar to exploratory drilling, commences. Generally, a number of wells are drilled from a single platform. Directional drilling–a standard practice which directs the drill off a vertical line to reach lateral sections of the oil or gas reservoir–makes the most economical use of the expensive platforms. Figure 4-8 illustrates the use of directional drilling to reach remote sections of a reservoir.

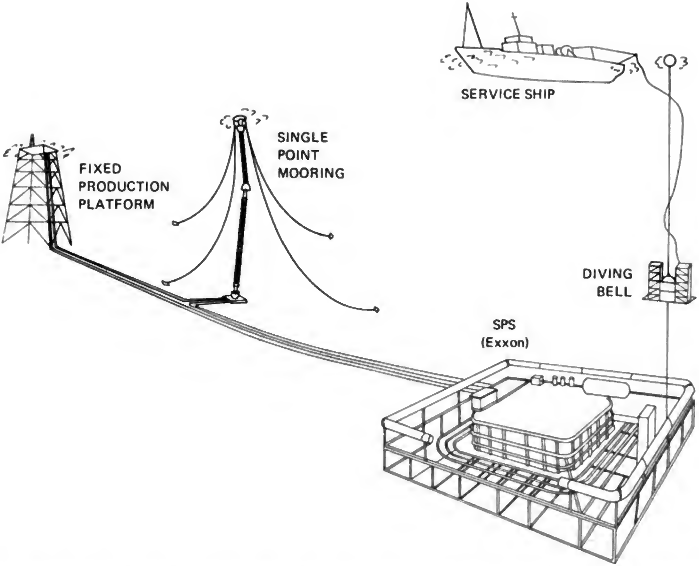
If commercial quantities of oil or gas are found, the well is completed, a term describing various steps in preparing a well for production:

> Completion can include setting and cementing casing, perforating (cutting holes in the casing which will permit oil or gas to flow from the formation into the well hole), fracturing



Source: Tetra Tech, Inc., 1973, "The Effect of Natural Phenomena on OCS Gas and Oil Development," prepared for the Council Environmental Quality under contract No. EQ4AC010.

Figure 4-6. A Fixed Drilling Platform



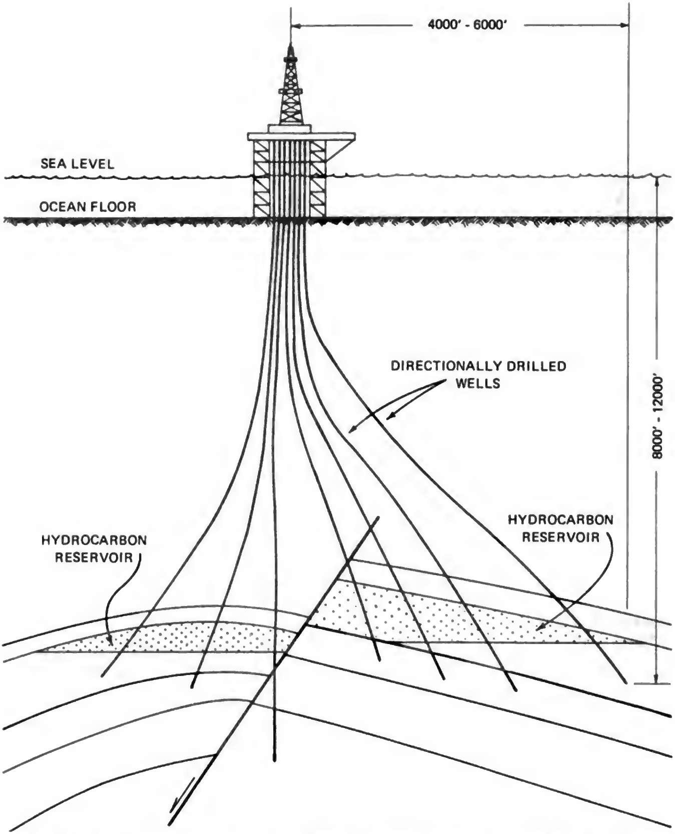
Source: Paper by C.C. Taylor, Exxon Company, U.S.A., "Status of Completion/Production Technology for the Gulf of Alaska and the Atlantic Coast Offshore Petroleum Operations," presented at the Resources for the Future, Inc., seminar, Washington, D.C., Dec. 5-6, 1973, conducted for the Council on Environmental Quality under contract No. EQ4AC003.

Figure 4-7. Subsea Production System: Exxon's Multiple Well Wet System

> (applying pressure or using explosives to increase [formation] permeability), acidizing (using acid to enlarge openings in the formation), consolidating sand (to keep sand from entering the well bore), setting tubing (conduit for routing the oil or gas to the surface), and installing downhole safety devices (valves installed to prevent blowouts during production).... If performed after initial completion, they are considered servicing or workover operations. [4]

Development drilling is generally less hazardous than exploratory drilling because the characteristics of the geological formations are better known. The potential threat of a blowout, however, remains. The severity of a development well blowout increases significantly if oil or gas is being produced simultaneously from wells already completed.

If a dry well is drilled, it is plugged with cement and abandoned. If a well is to be abandoned, either because it is a dry well or all the economically recoverable resource has been extracted, then all casing and piling are severed to at least 15 feet below the ocean floor and are removed. In the past, stubs of casing and piling extending above the bottom have interfered with fishing and navigation. Current procedures for OCS well abandonment are covered in OCS Order No. 3. [5]



Source: Paper by C.C. Taylor, Exxon Company, U.S.A., "Status of Completion/Production Technology for the Gulf of Alaska and the Atlantic Coast Offshore Petroleum Operations," presented at the Resources for the Future, Inc., seminar, Washington, D.C., Dec. 5-6, 1973, conducted for the Council on Environmental Quality under contract No. EQ4AC003.

Figure 4-8. Typical Directionally Drilled Wells

Production

Once a well is completed and connected to production facilities, production may begin. If oil, gas, and other materials are produced, they must be separated. The oil is separated, metered, and pumped to shore by pipeline, to offshore storage tanks for eventual transfer to a tanker, or directly to a tanker. The gas is separated; if it contains water, it is dehydrated by contacting it with glycol; and then it is pressurized, metered, and pumped to shore by pipeline. Where there is no gas pipeline or OCS gas production is not economical under prevailing market conditions, the gas is pressurized and reinjected into the reservoir. The flow diagram for a typical production facility is presented in Figure 4-9.

When water is produced with the oil, separation is required. Consistent with OCS Order No. 8, [6] separated water may be discharged into the ocean. The maximum allowable oil content is 100 parts per million; the average allowable oil content is 50 parts per million or less. Sand produced with the oil may be discarded into the ocean after the oil has been removed, as required in OCS Order No. 7. [7]

Because of possible explosions and fire, storms, and earthquakes, many devices are installed to warn of impending or existing dangers and to control or stop the flow of gas and oil if trouble is sensed. Some of the safety devices with which fixed platform production facilities are equipped are pressure, level, and combustible gas sensors; manual, automatic, and pressure relief valves; and fire detection and fighting equipment. In addition, each well is equipped with a subsurface safety valve which can shut the well down in case of surface equipment failure. Required safety and pollution control equipment and procedures are described in OCS Order No. 8. [8]

Although production is a continuous activity, it is sometimes necessary to shut down and reenter a well to improve or restore production. A variety of operations may be involved in workover and servicing, including further drilling to deepen the well. Because the well may be active and/or open, well control is the primary safety consideration, requiring the use of blowout prevention equipment.

Oil and Gas Transportation

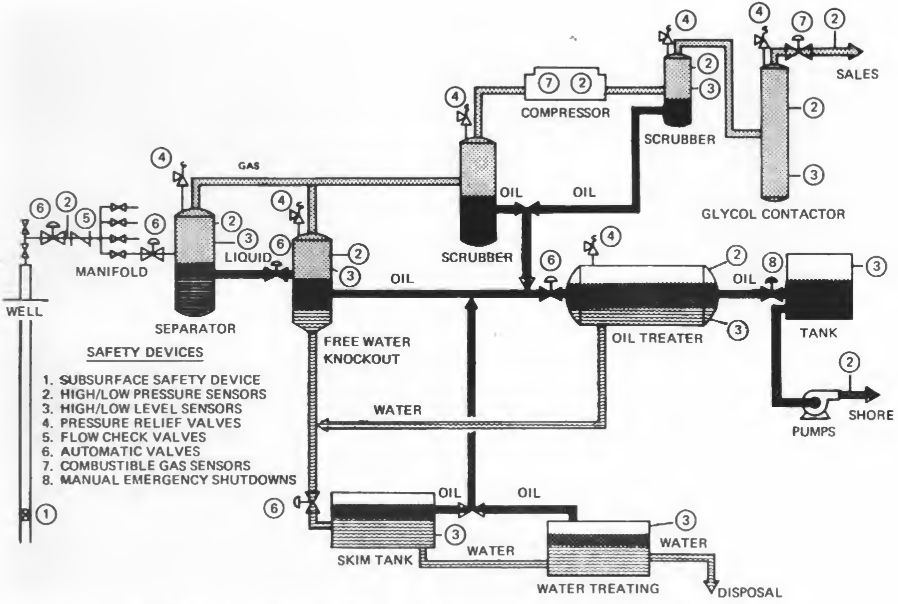
Crude oil and natural gas liquids may be transported to onshore processing facilities by pipeline or by tanker or barge. Natural gas is transported only by pipeline. All the natural gas now produced in the Gulf of Mexico and off Southern California is transported to shore by pipeline. All the oil produced off California and 97 to 98 percent of the Gulf oil is piped to shore. [9] Because most of the OCS geological formations with oil and gas potential lie within 200 miles of shore, pipelines will probably continue as the preferred OCS transportation mode.

Tankers may well be used for transporting oil during the early phases of field development in areas remote from established producing fields. Production can begin earlier, particularly far offshore, if tankers are loaded from offshore moorings in or near the field. One commonly used is the single point mooring. Production has begun in the North Sea Ekofisk and Auk Fields although the pipelines for these fields have not yet been completed. Tankers are being used and may continue to be used for supplemental transportation after the pipelines are completed. The environmental and economic consequences of various transportation modes for crude oil are examined in Chapter 8.

Pipelines. Pipelines transport large volumes of oil and natural gas. Once the pipeline route is selected and the volume to be pumped is determined, pipe size and strength are selected and line pressures calculated. Considered during route selection are bottom and subsurface foundations; current, wave, and tide conditions; and other uses–shipping, commercial fishing, naval operations, etc.–of the area to be crossed.

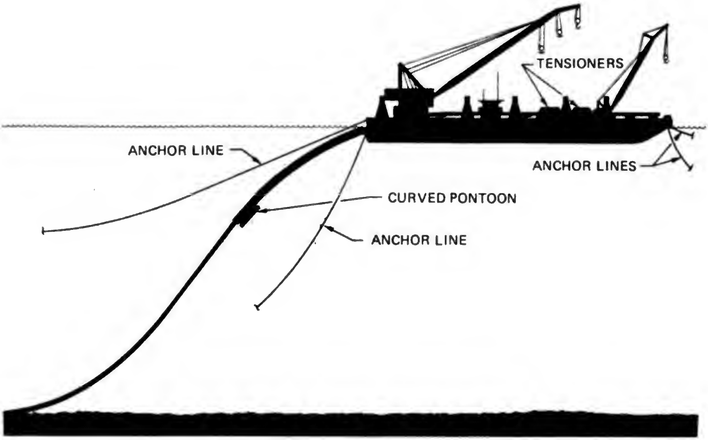
In the past, pipelines were generally laid directly on the ocean bottom. Burial of pipelines which lie in less than 200 feet of water is now required. Doing so minimizes the potential for damage from natural forces and from marine equipment such as anchors.

Primary techniques for laying pipe in coastal waters are section-by-section or "stove pipe," reel barge, and pipe pulling. In the stove pipe method, short sections of pipe are welded together on a pipelaying barge. While the barge moves slowly forward, the completed pipeline is released into the water and laid on the ocean floor. There are several types of barges and several ways to lower the pipe. The vessel may have a barge or ship hull or it may be semisubmersible. The barge hull is the most common, although it limits operations to relatively calm seas–6- to 14-foot waves. Semisubmersible hulls are the most stable. Behind the barge, the welded pipe section is supported by a pontoon or "stinger" that reduces stress caused by the pipe's own weight. The two most commonly used pontoons are the straight, rigid stinger and the curved stinger. The curved pontoon is illustrated in Figure 4-10.



Source: Paper by C.C. Taylor, Exxon Company, U.S.A., "Status of Completion/Production Technology for the Gulf of Alaska and the Atlantic Coast Offshore Petroleum Operations," presented at the Resources for the Future, Inc., seminar, Washington, D.C., Dec. 5-6, 1973, conducted for the Council on Environmental Quality under contract No. EQ4AC003.

Figure 4-9. A Typical Production Facility with Safety Equipment



Source: Paper by W.B. Pieper, Senior Vice President, Brown & Root, Inc., "Construction of Oil and Gas Pipelines and Oil Storage Facilities on the Outer Continental Shelf," presented at the Resources for the Future, Inc., seminar, Washington, D.C., Dec. 5-6, 1973, conducted for the Council on Environmental Quality under contract No. EQ4AC003.

Figure 4-10. A Lay Barge with Curved Pontoon

In the reel barge method, pipe is welded together onshore and is wound onto a large reel on the pipelaying barge. The pipe is laid as it unwinds. For pipe diameters in the 4- to 10-inch range, reel barges are often more economical than other types of barges. The technique is limited to pipe diameters of 12 inches or less.

Pipe pulling uses barges and tugs to pull sections of welded pipe from an onshore launchway over the pipeline route. This method is limited to pipeline of relatively small diameter and short length. Generally, it is used only for laying pipelines nearshore.

Pipelines in nearshore areas are usually laid in dredged canals. Generally, two methods are used in marshes and wetlands: the "push" technique and the floatation method. In the push technique, a relatively small canal (up to 6 feet deep and 10 feet wide) is dredged. Sections of pipe are joined at the beginning of the canal, and the pipe is simply shoved along in the canal. Then the ditch is usually backfilled. This method requires relatively firm ground for the dredging equipment (usually a dragline) but is generally less costly than floatation.

The floatation method requires a wider canal to provide access for the pipelaying equipment. The canal is 40 to 50 feet wide and 6 to 8 feet deep; it may have an additional trench in the bottom to provide a 10- to 12-foot clearance over the pipeline. Lay barges are often used in marshes because of the soft and unstable ground. Dredged material placed along the sides of the canal forms a low, flat levee. In most cases, the floatation canal is not backfilled because the dredge spoil is usually very fluid and tends to disperse. Loss of spoil through dispersion reduces the material available for complete backfilling.

In the Gulf of Mexico, levees have generally been continuous, with few or no openings. Openings are now required to minimize disturbance to drainage patterns. Plugging the canal ends, known as bulkheading, is required to minimize erosion, intrusion of saline water, and damage from navigation when the canal intersects a waterway.

Pipelaying in wetlands can cause serious adverse physical and biological impacts. Natural drainage and water current patterns can be disrupted. Erosion of soft and unconsolidated sediments in marshlands can be markedly accelerated. Biologically productive land can be lost. Disturbance of marshlands can change turbidity, salinity, acidity, hydrogen sulfide toxicity, and biological oxygen demand.

Tankers and Barges. Although tankers and barges transport less than 3 percent of the oil produced in the Gulf of Mexico, as stated earlier, tankers may be used in the initial phases of field development in Atlantic and Gulf of Alaska OCS areas. Transportation of oil by tanker has recently received considerable attention because of the development of Very Large Crude Carriers (VLCC) or supertankers and because of subsequent proposals for siting superports off U.S. coasts. Because a supertanker is economically advantageous only over great distances–from the Persian Gulf to the United States, Western Europe, or Japan, for example–VLCC's will probably not be used in OCS operations.

Conventional oil tankers and barges are now used extensively in U.S. coastal waters. In 1972, the Atlantic coast states (included in Petroleum Administration District No. 1) received 91 percent of their domestic crude oil supply (290,000 barrels per day) by tanker and barge from the Gulf of Mexico and 89 percent of their foreign crude oil imports (970,000 barrels per day) by tanker and barge. [10]

Oil pollution from tankers and barges results from collisions and groundings and from operational problems such as equipment failure, human failure, and intentional discharges. Release of 700,000 barrels of oil from the TORREY CANYON in 1967 is probably the most widely known tanker catastrophe, although the largest spill, 800,000 barrels of oil, resulted from a tanker breakup off Africa in 1972. Oil spill statistics from OCS oil and gas production operations are discussed in a subsequent section of this chapter.

The major source of oil pollution from tankers is intentional discharge–the pumping of oily ballast water and tank washings into the oceans. Over 70 percent of all oil released from tankers is due to these routine operations. [11] Another important source of pollution from tankers is spillage as oil is being transferred to and from tankers at marine terminals. Mechanical failure, faulty design, and human error account for most of this spillage.

Single point moorings (SPM), also known as single buoy moorings (SBM), have recently been developed to reduce the hazards of storms to tankers and to minimize oil spills during loading. Over 100 SPM's are in use throughout the world. One example was shown in Figure 4-7. A tanker is moored to a single point, and loading hoses are connected between it and the buoy. Because the mooring and hoses can circle the buoy, the tanker moves to head into waves, tides, and storms. The SPM thus allows a tanker to remain moored in 15- to 20-foot waves accompanied by winds and currents; these conditions could not be tolerated at a fixed mooring.

In addition to oil pollution, tankers and barges pollute with their sewage, untreated garbage, and human wastes. A tanker of 35,000 deadweight tons generates about 1,000 gallons per day each of sewage and domestic wastes. [12] If they are not treated, they can significantly degrade water quality, particularly in harbors and bays.

Offshore Oil Storage

As development proceeds farther from shore, it may become economical to store the oil offshore temporarily while awaiting tankers. This is especially important when severe weather conditions prohibit the mooring of tankers for extended periods of time.

Three types of offshore oil storage systems are now being used in various parts of the world–elevated, floating, and bottom standing.

The size of an elevated storage facility is severely limited because it must be mounted on a platform far enough above the water surface to avoid wave action during the most severe storms. The structural capability of the platform, then, is the limiting factor. In the Gulf of Mexico, maximum storage capacity on an individual platform is 10,000 barrels. [13]

Several large floating storage barges are now in use. The 1-million-barrel barge, PAZARGAD, is a storage, desalting, and loading facility in the Persian Gulf.[14] It employs an SPM system in order to head into the winds and currents and to withstand storms better. Another barge of the same volume, also moored to an SPM, is being used off Indonesia. [15]

Storage facilities which rest on the ocean floor either may be submerged or may extend above the water surface. The most outstanding examples are the three dome-shaped tanks of the Dubai Petroleum Company in the Persian Gulf and the cylindrical concrete tank of the Phillips Group in the North Sea. The Dubai tanks stand in 155 feet of water. Each has a capacity of 500,000 barrels. Oil is loaded into tankers from an SPM. [16]

The Phillips tank, with a capacity of 1 million barrels, stands in 230 feet of water. Production equipment is mounted on top of the tank which extends nearly 100 feet above sea level (see Figure 4-11). The side of the tank is protected from wave action by a perforated outer wall. Beginning in mid-1974, oil will be loaded from the tank into tankers through two SPM systems. [17]

Oil Spill Containment and Cleanup

The thrust of industry and government efforts to improve the reliability and safety of OCS operations has been prevention of spills and other accidents. Shortly after the TORREY CANYON accident in 1967, the President ordered the development of an oil pollution contingency plan. The National Oil and Hazardous Substances Pollution Contingency Plan was incorporated into the Federal Water Pollution Control Act in 1970 and retained in the Amendments of 1972. [18] The industry has organized a number of cleanup cooperatives. The major ones are Clean Seas, Inc., in California and Clean Gulf Associates in Louisiana.

Both Government and industry research and development have resulted in improved oil spill containment and cleanup devices. The floating boom is the primary containment device to date. Cleanup is effected mainly by mechanical gathering and sorbent recovery. Two other cleanup techniques involve use of dispersing agents and combustion. Of course, natural physical and biological processes always come into play, especially if the spill is far from shore.

Containment. Booms contain an oil slick by encircling, sweeping, or directing it to a collection point or by a combination of these efforts. The boom's floatation system may be a part of or separate from the containment section. Typically a fence or skirt extending above and below the water surface forms the containment section.

The effectiveness of a boom is limited by waves, winds, and currents. Most booms fail because as the oil accumulates, currents carry it under the boom. Further, in turbulent seas when wave heights exceed 10 feet, a true oil slick does not form. Rather, oil droplets are dispersed in the water column and neither containment nor cleanup is possible.

To date the best boom performance that has been reported (Exxon) is containment in 6- to 8-foot seas with 20-mile winds and 1.25-mile currents. [19] The U.S. Coast Guard has developed a mechanical containment and recovery system for the open ocean with a capability of 50 barrels per minute. Work continues to obtain improved performance, but because of turbulence, the effectiveness of booms and recovery systems is nearing its upper limit. Only in relatively calm waters are booms generally effective. In open seas, oil spill containment is severely limited.

Cleanup. Mechanical cleanup devices are also generally limited to calm waters. They operate at low recovery rates–generally 1 to 5 barrels per minute–and thus are of limited effectiveness for large spills. [20]

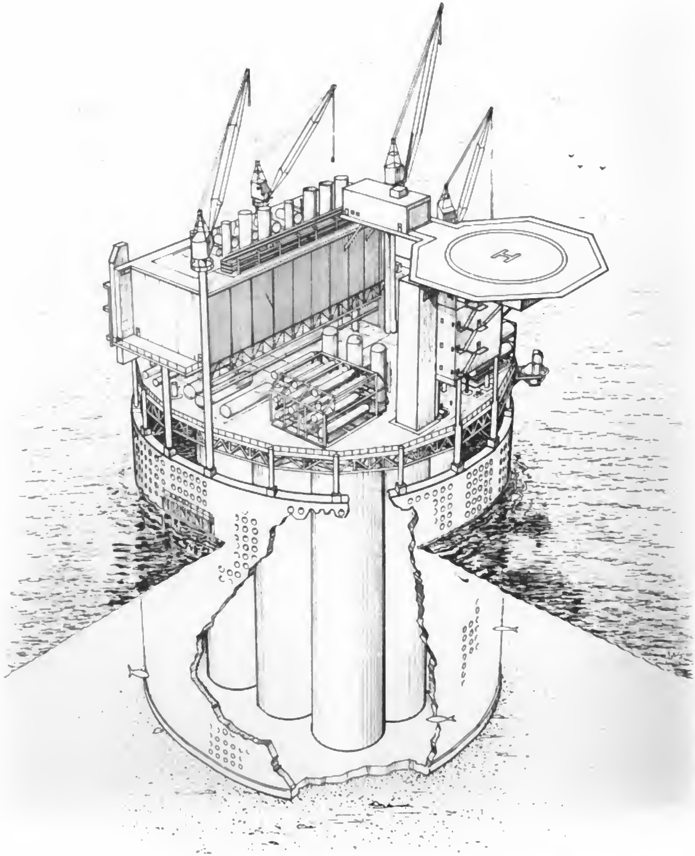
Straw, manufactured fibers, and absorbent clays are spread on a slick, mixed with the oil, and collected. Straw is considered the most cost-effective sorbent because it holds five times its weight in oil and costs $25 to $50 per ton. There are serious logistical problems in spreading and collecting the sorbents as well as disposing of the oil-contaminated materials. [21]

Use of dispersants in U.S. coastal waters is strictly limited by the National Contingency Plan because of their potentially toxic effects on marine organisms. Dispersants are, however, used widely in the United Kingdom except in designated critical environmental areas. Use of burning and sinking agents is also limited by the plan. These materials have been limited because they do more harm to the marine biota than the oil.

OCS ACCIDENTS, OIL SPILLS, AND CHRONIC DISCHARGES

From 1953 through 1972, when nearly all the wells were drilled in the U.S. OCS, 43 major accidents occurred (see Table 4-2). [22] Nineteen were associated with drilling, 15 with production, and 4 with pipelines. Over the 19 years, there has been an average rate of 0.005 (0.5 percent) drilling and production accidents per successful OCS well drilled. During the same period, 8 blowouts were recorded in state waters. [23]

The frequency of OCS accidents generally increased as activity increased until 1968, when the accident frequency peaked. It has been decreasing since then. The 1969 Santa Barbara blowout–in releasing from 18,500 to 780,000 barrels of oil–raised serious questions on the adequacy of OCS technology. Since Santa Barbara, three major production platform accidents



Source: Tetra Tech, Inc., 1973, "The Effect of Natural Phenomena on OCS Gas and Oil Development," prepared for the Council on Environmental Quality under contract No. EQ4AC010.

Figure 4-11. The Phillips Petroleum Underwater Storage Tank Being Installed in the North Sea

TABLE 4-2

Major Accidents on the U.S. Outer Continental Shelf, 1953-1972

Results	Drilling	Production	Pipeline	Collision	Weather	Total
Number	19	15	4	2	3	43
Oil	0	3	4	1	3	11
Oil and gas	2	7	0	0	0	9
Gas	17	2	0	0	0	19
Other	0	3	0	1	0	4
Oil spills	2	10	4	1	3	20
Oil volume (thousand barrels)	18.5-780	84-135.4	175	2.6	9.2-9.7	290-1,100
Deaths	23	33	0	0	0	56
Injuries	7-8	91-100	0	0	0	98-108
Fires	7	12	0	1	0	20
Major rig/platform damage	4	9	0	2	0	15
Duration	2 hrs.-5.5 mos.	10 min.-4.5 mos.	1-13 days	1 day	1-3 days	10 min.-5.5 mos.

Sources: University of Oklahoma Technology Assessment Group, *Energy Under the Oceans: A Technology Assessment of Outer Continental Shelf Oil and Gas Operations* (Norman: University of Oklahoma Press, 1973), using U.S. Geological Survey, U.S. Coast Guard, *Offshore*, and *Oil and Gas Journal* data.

have occurred in the Gulf of Mexico. In the Shell accident (1970), estimates of oil lost range from 53,000 to 130,000 barrels. The Chevron accident (1970) resulted in loss of 30,500 barrels, and the Amoco accident (1971) resulted in loss of 400 to 500 barrels.

The diminishing number of drilling accidents since 1968 reflects improvements in both technology and practice. The frequency of production accidents has not decreased so markedly, perhaps because in all instances old offshore production facilities and pipelines do not meet the specifications now called for in new facilities and pipelines.

Oil Spills

Although accidents during offshore operations account for only a small portion of the oil that is spilled, locally they can be significant. Their frequency and magnitudes and the fate and effects of the oil are important factors in OCS development decisions. The Council on Environmental Quality contracted with ECO, Inc., and with the Massachusetts Institute of Technology to analyze the probability of offshore oil spills. The results of their efforts are summarized in this section. [24] Sources of data used in their study were:

- Coast Guard Pollution Incident Reporting System
- ECO, Inc., data base on tanker casualties (1968–1972)
- Petroleum Systems Reliability Analysis data base generated by Computer Sciences Corporation for the Environmental Protection Agency
- M.I.T. data base on large spills
- A sample of 300 spills at single point moorings worldwide, principally from testimony at hearings before the House of Lords on a proposed Anglesey, England, terminal.

The most important general features of oil spill statistics are the following:

- The size range of individual spills is extremely large, from a fraction of a barrel to over 150,000 barrels.
- Most spills are at the low end of this range; in 1972, 96 percent was less than 24 barrels (1,000 gallons) and 85 percent was less than 2.4 barrels (100 gallons).
- A few very large spills account for most of the oil spilled (the TORREY CANYON accident of 1967 spilled twice as much oil as was reported spilled in the United States in 1970). In 1970 and 1972, three spills each year accounted for two-thirds of all oil spilled in the United States in those years.

These facts are highlighted in order to point out the meaninglessness of estimating "average" amounts of oil that might be spilled at particular steps in the development process. Amounts spilled can vary by a factor of 1 million, and single spills like the TORREY CANYON distort the statistical distribution of spill magnitudes. Further, as shown in Table 4–3, fluctuations from year to year are quite large.

TABLE 4-3

Oil Spill Statistics

[Barrels]

Type of spill	1971	1972
Petroleum industry-related spills		
Terminal		
Number	1,475	1,632
Volume	125,800	54,700
Ships (offshore)		
Number	22	32
Volume	400	51,600
Offshore production facilities		
Number	2,452	2,252
Volume	15,600	5,700
Onshore pipeline		
Number	74	162
Volume	8,700	28,300
Total		
Number	4,023	4,078
Volume	150,500	141,300
All spills		
Number	7,461	8,287
Volume	205,000	518,000

Source: The Massachusetts Institute of Technology Department of Ocean Engineering, 1974, "Analysis of Oil Spill Statistics," prepared for the Council on Environmental Quality under contract No. EQC330, using U.S. Coast Guard data.

Certain patterns emerge from the statistical analysis of oil spills. For the four major sources of offshore oil pollution, Table 4-4 shows a remarkable similarity in the number of oil spills in each volume category for 1971 and 1972. The data suggest that the same processes, equipment inadequacies, and operator errors are causing the spills. Computer Sciences Corporation, under contract to EPA, recently analyzed the failures and errors that have caused these spills. [25] Although restricted by the limited data base, the study suggests that remedy of certain technological and operational inadequacies could significantly reduce the number and size of oil spills. Similarly, USGS has analyzed its oil spill data and is incorporating the results into the Federal inspection and enforcement program.

Platforms and Pipelines. Between 1964 and 1972, there were relatively few large spills from platforms and pipelines (Table 4–5 lists the spills of more than 1,000 barrels of oil). For an oil field find of medium size* there is about a 70 percent chance that at least one platform spill over 1,000 barrels will occur during the life of the field. For a small oil field find, there is about a 25 percent chance of one platform spill over 1,000 barrels, and for a large oil field find, there is over a 95 percent chance of a platform spill over 1,000 barrels during the life of the fields. The probability of pipeline spills follows the general pattern exhibited by platform spill statistics. Figure 4-12, which shows the volume of oil handled on a platform between successive spills, indicates that there is about a 40 percent chance that 250 million barrels of oil will be handled between large spills. If a large platform spill does occur, there is an 80 percent chance that the volume will exceed 2,380 barrels and a 35 percent chance that it will exceed 23,800 barrels.

Figure 4-12 also shows that the probability of successive spills increases rapidly as the size of the find increases. Conversely, this means that large spills will occur more often–for an equal increase in probability of a spill, 4.5 years will elapse in a small find and only 1.0 year elapses in a large find. Biologically, the time between large spills may be at least as important as the number of such spills. The ability of ecosystems to recover between successive oil spills is discussed in Chapter 6.

Tankers. About 98 percent of all the oil spilled by vessels is from incidents involving over 1,000 barrels. Most large tanker spills occur within 50 miles of land. Most result from groundings, rammings (the vessel hits a fixed structure), or collisions. Groundings and rammings occur nearshore, and collision frequency depends on traffic density, which is highest nearshore.

Analysis of tanker spill statistics indicates that if tankers are used to transport the oil to shore, the probability that there will be one tanker spill over 1,000 barrels is about 27 percent during the life of a small find, about 85 percent for a medium find, and nearly 100 percent for a large find. As the size of the find increases, so do the number of expected spills and the overall probability that a spill will occur (see Figure 4-13).

The possibility of more frequent or larger oil spills resulting from use of single point moorings was also analyzed. One might expect more spillage at SPM's than at fixed berth facilities because the SPM adds ship motion, flexible hoses subject to wave action, and possible loss of mooring to normal loading operations.

There have been 108 SPM spills in 5,578 ship calls,

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*A medium find was defined by M.I.T. as 2 billion barrels of oil in place and a gas/oil ratio of 1,000:1. A small find was defined as 500 million barrels of oil and 500 billion cubic feet of gas and a large find as 10 billion barrels of oil.

TABLE 4-4

Petroleum Industry-Related Oil Spill Volumes
[Gallons] [1]

Facility	0-1	1-10	10-100	100-1,000	1,000-10,000	10,000-100,000	100,000-1,000,000	1,000,000-10,000,000
Terminal								
1971	384	247	458	282	77	19	7	1
1972	351	347	544	298	71	16	5	0
Ship (offshore)								
1971	4	6	8	0	4	0	0	0
1972	15	2	10	3	0	0	1	1
Pipeline								
1971	222	403	496	257	41	13	2	0
1972	15	24	61	61	32	7	3	0
Platform								
1971	227	304	395	146	13	2	0	0
1972	431	784	728	244	20	4	0	0
Total								
1971	837	960	1,357	685	135	34	9	1
1972	812	1,157	1,343	606	123	27	9	1

[1] Forty-two gallons equals 1 barrel. Gallons, rather than barrels, are used to illustrate the fact that most spills involve a small volume of oil.

Source: Massachusetts Institute of Technology, "Oil Spill Trajectory Studies for Atlantic Coast and Gulf of Alaska," *Primary, Physical Impacts of Offshore Petroleum Developments,* prepared for the Council on Environmental Quality under contract No. EQC330 (Cambridge: Massachusetts Institute of Technology, 1974), Report No. MITSG 74-20.

or 1 spill for every 50 calls. By comparison, the fixed berth terminal at Milford Haven, England's largest oil port, reports 1 spill every 60 ship calls through 1972. Individual SPM's may not do so well. An unloading SPM at Durban, South Africa, reported 1 spill every 5 ship calls in 1971. The data that M.I.T. collected show little difference in the size of spills from SPM's and from fixed berth moorings. The average spill at SPM's is about 7 barrels, roughly equal to Milford Haven's experience at fixed berth terminals. [26]

Total Volume of OCS Oil Spills

The total volume spilled over the life of a field, although not as important as the frequency and magnitude of individual spills, is of interest. Table 4-6 shows that the number and total volume of spills for platforms, pipelines, and tankers are of the same order of magnitude for a given field size. Platforms have the lowest frequency and volume and tankers the highest.*

If the oil from a small field is transported by tanker, the probability that there will be no spill over 1,000 barrels is 52 percent; if oil is transported by pipeline, the probability is 75 percent. There is a higher probability of an extremely large spill from large pipelines than from tankers. Thus, if massive (above 240,000 barrels) spill volumes, which have a low (less than 1 percent) probability of occurring, are the main concern, tankers may be preferred over pipelines.

In interpreting these data, one must keep in mind that they are based on past experience and do not adjust for future improvements or production economics. If low-productivity OCS fields are discovered, replacement of pipelines 15 to 20 years into the field's life may be uneconomical; this could lead to higher incidence of pipeline leaks. Pipeline spill data include three major shallow water spills which may not be relevant to the Atlantic or Gulf of Alaska. The tanker spills include those from ships registered in all nations; however, American ships have a better record than all others.

Chronic Discharges

Several routine OCS operations result in discharges of oil and other materials to the water. Unlike that for

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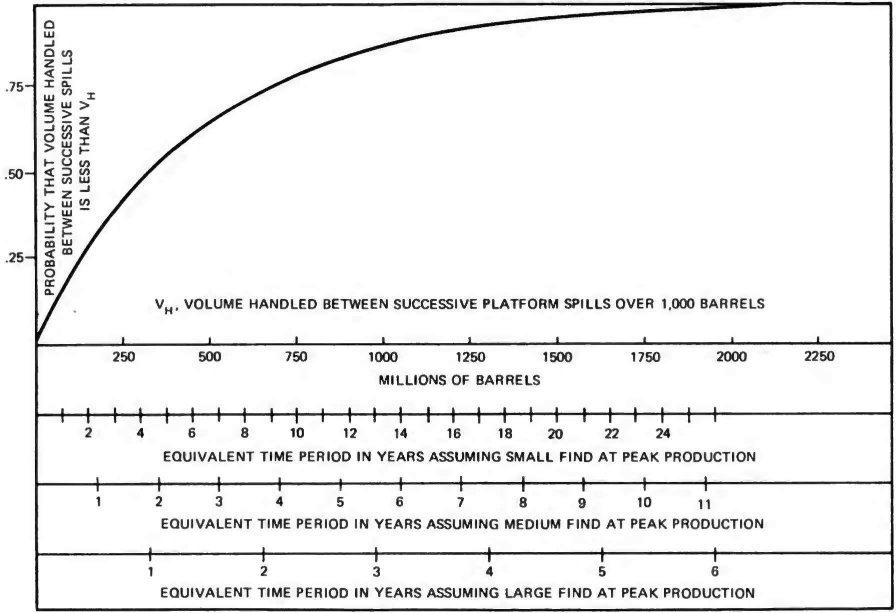
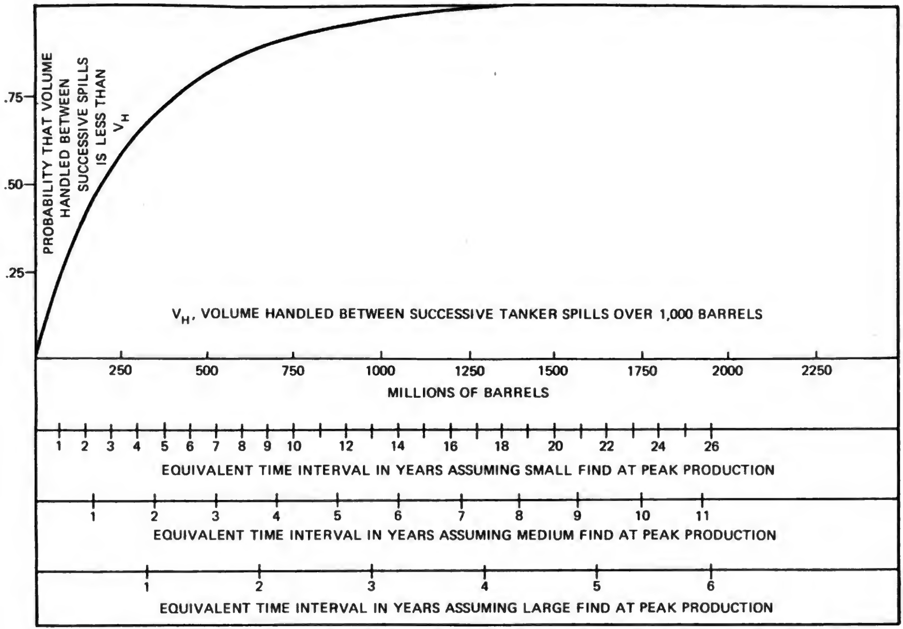
*Although the M.I.T. approach does not consider average spillage rates valid, mean spill rates were derived at the request of the Council. M.I.T.'s computed ratio of the mean spill rate to the total volume of oil handled for platforms is 0.006 percent, for offshore pipelines is 0.011 percent, and for tankers is 0.016 percent. [27]



Source: Massachusetts Institute of Technology, "Oil Spill Trajectory Studies for Atlantic Coast and Gulf of Alaska," *Primary, Physical Impacts of Offshore Petroleum Developments,* prepared for the Council on Environmental Quality under contract No. EQC330 (Cambridge: Massachusetts Institute of Technology, 1974), Report No. MITSG 74-20.

Figure 4-12. Cumulative Volume of Oil Handled Between Platform Spills Larger than 1,000 Barrels



Source: Massachusetts Institute of Technology, "Oil Spill Trajectory Studies for Atlantic Coast and Gulf of Alaska," *Primary, Physical Impacts of Offshore Petroleum Developments*, prepared for the Council on Environmental Quality under contract No. EQC330 (Cambridge: Massachusetts Institute of Technology, 1974), Report No. MITSG 74-20.

Figure 4-13. Cumulative Volume of Oil Handled Between Tanker Spills Larger than 1,000 Barrels

TABLE 4-5

Major Oil Spills from Offshore Production Facilities, 1964-1972[1]

	Cause	Date	Amount reported (barrels)
Offshore platforms			
Union "A," Santa Barbara	Blowout	January 28, 1969	77,400
Shell ST 26 "B," La.	Fire	December 1, 1970	52,400
Chevron MP 41 "C," La.	Fire	March 10, 1970	30,950
MP gathering net and storage, La.	Storm	August 17, 1969	12,200
Signal SS 149 "B," La.	Hurricane	October 3, 1964	5,000
Platform, 15 miles offshore	–	July 20, 1972	4,000
Continental EI 208 "A," La.	Collision	April 8, 1964	2,600
Mobil SS 72, La.	Storm	March 16, 1969	2,500
Tenneco SS 198 "A," La.	Hurricane	October 3, 1964	1,600
Offshore pipelines			
West Delta, La.	Anchor dragging	October 15, 1967	157,000
Persian Gulf	Break	April 20, 1970	95,000
Coastal channel, La.	Hit by tug prop	October 18, 1970	25,000
Chevron MP 299, La.	Unknown	February 11, 1969	7,400
Gulf ST 131, La.	Anchor dragging	March 12, 1968	6,000
Coastal channel, La.	Equipment failure	December 12, 1972	3,800
Coastal waters, La.	Leak	March 17, 1971	3,700
Coastal channel, Tex.	Leak	November 30, 1971	1,000
Coastal channel, La.	Leak	September 28, 1971	1,000

[1] Over 1,000 barrels.

Source: Massachusetts Institute of Technology, "Oil Spill Trajectory Studies for Atlantic Coast and Gulf of Alaska," *Primary, Physical Impacts of Offshore Petroleum Developments*, prepared for the Council on Environmental Quality under contract No. EQC330 (Cambridge: Massachusetts Institute of Technology, 1974), Report No. MITSG 74-20.

accidental spills, their probability is 1.0–they have a 100 percent chance of occurring. Some scientists believe that over the life of a field these intentional releases may damage the environment as much as the large accidental oil spill.

Securing platforms with pilings or anchors, anchoring vessels, and burying pipelines offshore disturb bottom sediments and increase turbidity.

In most drilling operations, cleaned drilling mud and drill cuttings are discharged overboard. Drill cuttings are shattered and pulverized sediment and native rock. Drilling mud may consist of such substances as bentonite clay, caustic soda, organic polymer, proprietary defoamer, and ferrochrome lignosulfonate. During the course of drilling an average 15,000-foot well, approximately 110 tons of commercial mud components and 950 tons of drill cuttings are discharged overboard. [28] In its environmental impact statement on the proposed OCS lease sale in the northeast Gulf of Mexico, the Bureau of Land Management estimated that a maximum of 1 million tons of drill cuttings and

TABLE 4-6

Oil Spilled Over the Life of a Field

	Number of spills	Total volume (barrels)
Small Find		
Platform	0.28	7,200
Pipeline	0.31	13,900
Tanker	0.41	19,900
Medium Find		
Platform	1.3	33,300
Pipeline	1.4	62,900
Tanker	1.9	92,400
Large Find		
Platform	4.7	120,500
Pipeline	5.2	233,300
Tanker	6.9	335,700

Source: Massachusetts Institute of Technology, "Oil Spill Trajectory Studies for Atlantic Coast and Gulf of Alaska," *Primary, Physical Impacts of Offshore Petroleum Developments*, prepared for the Council on Environmental Quality under contract No. EQC330 (Cambridge: Massachusetts Institute of Technology, 1974), Report No. MITSG 74-20.

123,000 tons of mud would be discharged in the area as a result of drilling 1,120 wells to an average depth of 15,000 feet. [29]

During operations, waters from the geological formations are often produced. The waters may be fresh or may contain mineral salts such as iron, calcium, magnesium, sodium, and chloride. Their discharge increases the mineral content and lowers dissolved oxygen levels in the area of operations. The waters often contain small amounts of oil. The potential impacts of continuous discharges are discussed in Chapter 6.

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Chapter 5. Natural Phenomena and OCS Development

An analysis of how operations would affect the environment in the Atlantic and Gulf of Alaska OCS is incomplete without discussing the natural phenomena that could impact operations in these areas. The environments of both areas are at times subject to the stress of earthquakes, tsunamis, ice, and severe storms. This chapter is based largely upon the results of a study prepared by Tetra Tech, Inc., to investigate the likelihood of such occurrences and their possible impacts and to compare these analyses with conditions in offshore areas that are already being developed. [1]

CLIMATE AND STORMS

The general surface wind pattern along the Atlantic coast is controlled for the most part by the position and intensity of the Bermuda-Azores high pressure system. Major low-pressure storm systems* usually move through the region in a north to east-northeast direction and are often accompanied by strong, gusty winds and heavy seas. These storms occur most often during the winter months when the Bermuda-Azores high is located far to the southeast, and their persistence for several days may generate high sustained winds. Hurricanes† occur frequently, most often from June through November; less than 3 percent occur at other times. From 1886 to 1972 about 80 percent occurred from August to October. The maximum winds along the Atlantic coast are associated with the hurricanes. The most dangerous element of a hurricane is the accompanying high tides as the storm moves across a coastal area.

Weather in the Gulf of Alaska is controlled primarily by the semipermanent Aleutian low. This system usually appears in September, moving gradually westward in winter and spring. The strongest pressure gradients generally occur in late fall and early winter, the stormiest part of the year. During most of the winter months, storms are more frequent in the Gulf of Alaska than in any other part of the Northern Hemisphere. They move through the Gulf from the west and southwest and out to the southeast.

The Middle and South Atlantic OCS are subjected to more severe storm conditions due to hurricanes than either the Gulf of Alaska or the North Sea. For example, storms with sustained winds‡ of at least 100 knots can be expected to occur over a 90-year period in the North Sea, whereas in the Gulf of Alaska the period would be 50 years, and in the Middle Atlantic it would be 30 years (see Figure 5-1). Further, significant wave heights** of 55 feet can be expected during a 100-year period in the Gulf of Alaska, a 60-year period in the North Sea, and a 25-year period in the Atlantic (see Figure 5-2). In fact, the highest significant waves were reported off the Middle Atlantic coast where 60- to 70-foot waves were encountered.

Recurrent severe weather is as important to daily OCS operations as maximum wind speed and wave heights are to structure design. Because the Gulf of Alaska generally has higher significant wave heights in the winter months than does the North Sea or the

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*Low-pressure storms are technically defined as extratropical cyclones and are generated by disturbances along the boundary between cold polar and warm tropical air masses.

†Hurricanes are one of the categories of tropical cyclones because they develop in the tropics. An average of 9.6 tropical cyclones (winds over 33 knots) form each year, of which about 5.6 reach hurricane intensity (winds over 64 knots).

‡Maximum sustained wind is defined as the average over a 1-minute period of the maximum measured wind. Maximum gust velocity is usually about 1.4 times the maximum sustained wind.

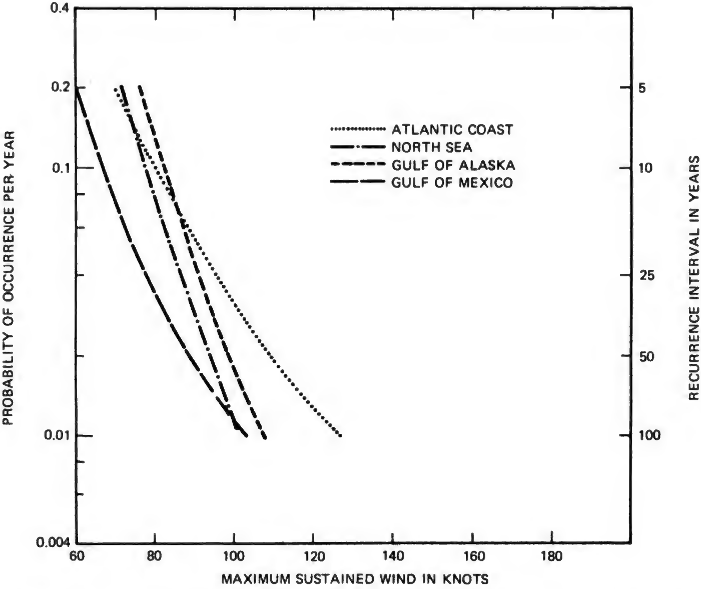
**Significant wave height is the average of the largest one-third of all waves.

Atlantic OCS, operational time in the winter months will be shorter in the Gulf than in the North Sea.

Severe weather affects exploratory drilling more than any other phase of operations. Waves can move a mobile platform enough to increase dynamic stresses on equipment handling devices and to cause seasickness. Because these factors increase accident risks, drilling should be halted when weather conditions approach the capability of rigs to operate safely.

In the North Sea drilling operations have been shut down for weeks at a time, especially during winter periods. In the last 4 years, semisubmersible drilling operations have experienced a 20 to 30 percent downtime attributable to weather from October through March. The annual average downtime in the North Sea operations has been about 15 percent. Although specific designs for the Gulf of Alaska would incorporate lessons learned in the North Sea, it is unlikely that the drilling season could be extended and costly downtime reduced significantly.

Severe weather should not pose as great a problem during production, especially if pipelines are used to transport the product to shore. If a single point mooring is used, inability to moor the tanker during severe weather could cause shutdowns. These shutdowns, estimated at 20 percent in the North Sea, can be re-



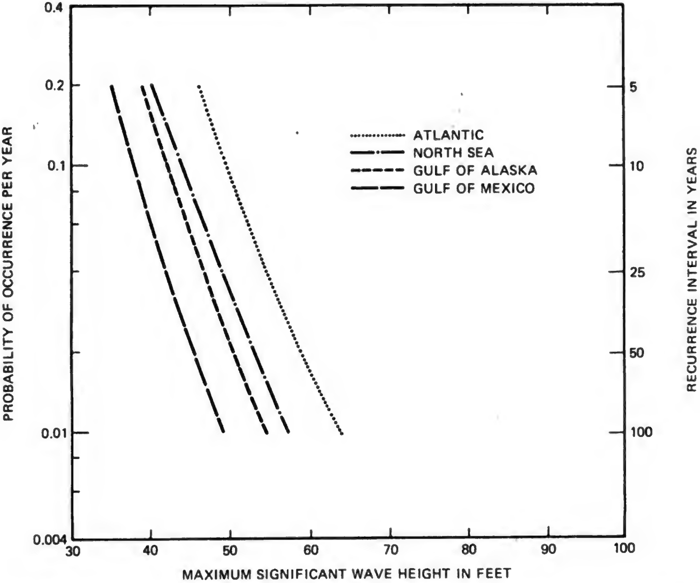
Source: Tetra Tech, Inc., 1973, "The Effect of Natural Phenomena on OCS Gas and Oil Development," prepared for the Council on Environmental Quality under contract No. EQ4AC010.

Figure 5-1. Maximum Sustained Winds for the Atlantic Coast, Gulf of Alaska, Gulf of Mexico, and North Sea

duced by increasing offshore storage capacity.

Icebergs and ice rafting should not be a major problem in Atlantic OCS areas under consideration. In the Georges Bank area, ice accretion on ships and offshore structures could be moderate (1.5 to 2.5 inches per hour) for up to a couple of days during February. Heating coils and similar devices can minimize ice accumulation and its hazards: the stress created by added weight, freezing of equipment, and safety of personnel. During the summer, fog may be a problem, especially in the North Atlantic.

In the Gulf of Alaska icing is a more serious problem; it happens more frequently and lasts longer. In February, moderate icing could occur 20 percent of the time, and severe icing--more than 2.5 inches per hour--almost 1 percent of the time. In addition, many glaciers are found on the perimeter of the Gulf of Alaska, and icebergs are frequently found in the glacial inlets. Because most of the icebergs cannot enter the open water, they are not an expected hazard.



Source: Tetra Tech, Inc., 1973, "The Effect of Natural Phenomena on OCS Gas and Oil Development," prepared for the Council on Environmental Quality under contract No. EQ4AC010.

Figure 5-2. Maximum Significant Wave Heights for the Atlantic Coast, Gulf of Alaska, Gulf of Mexico, and North Sea

EARTHQUAKES

The Atlantic OCS is an area of moderate seismic activity. Earthquakes comparable to about Richter magnitude 7.0 have been reported in the last several centuries, most in the North Atlantic. Earthquakes of this magnitude could damage most OCS structures and would damage foundations possibly to the point of collapse. Ground cracking will occur and landslides are to be expected. The 1929 Grand Banks earthquake (Richter magnitude 7.2) caused an extensive submarine slide which destroyed communication cables over a wide area. The coastal plain sediments east and south of the Appalachian Range also experience occasional strong shocks—an 1886 earthquake killed 60 people in Charleston, S.C.

The Gulf of Alaska is subject to frequent and severe earthquakes. Alaska and the Aleutian Islands are part of the great seismic belt that circumscribes the Pacific Ocean. Between 1899 and 1917, five earthquakes in the Gulf of Alaska area had magnitudes greater than 7.8 Richter. Since then eight have measured above 7.0 on the Richter scale (see Table 5-1).

TABLE 5-1

Major Gulf of Alaska Earthquakes, 1899-1973[1]

Greenwich date	Location		Magnitude on Richter scale
	Latitude	Longitude	
September 4, 1899	60N	142W	8.3
September 10, 1899	60N	140W	7.8
September 10, 1899	60N	140W	8.6
October 9, 1900	60N	142W	8.3
August 27, 1904	64N	151W	8.3
June 21, 1928	60N	146.5W	7.0
May 4, 1934	61.25N	147.5W	7.2
January 12, 1946	59.25N	147.25W	7.2
September 27, 1949	59.75N	149W	7.0
April 10, 1957	56N	154W	7.1
February 6, 1964	59N	156W	7.1
March 28, 1964	61.1N	147.6W	8.3-8.6
September 4, 1965	58N	152.5W	7.0

[1] From 1899 to 1917, the only earthquakes listed are those greater than Richter magnitude 7.7.

Source: Tetra Tech, Inc., 1973, "The Effect of Natural Phenomena on OCS Gas and Oil Development," prepared for the Council on Environmental Quality under contract No. EQ4AC010.

The 1964 Alaskan earthquake (Prince William Sound) was estimated at between 8.3 and 8.6 Richter. Significant damage extended over 90 miles from the epicenter, and permanent ground deformations occurred over 100,000 square miles. In the vicinity of Montague Island, the floor of the Gulf rose vertically about 30 feet and moved horizontally about 80 feet. In addition, widescale land slumping and slides were recorded throughout the central coastal area.

With data supplied by the National Oceanic and Atmospheric Administration, earthquake recurrences have been plotted for various areas (see Figure 5-3). Earthquakes of 7 Richter or greater are predicted once every 100 years in the Atlantic and about every 3 to 5 years in the Gulf of Alaska. In addition, earthquakes of 8 Richter or greater are predicted about once every 25 years in the Gulf of Alaska.

TSUNAMIS

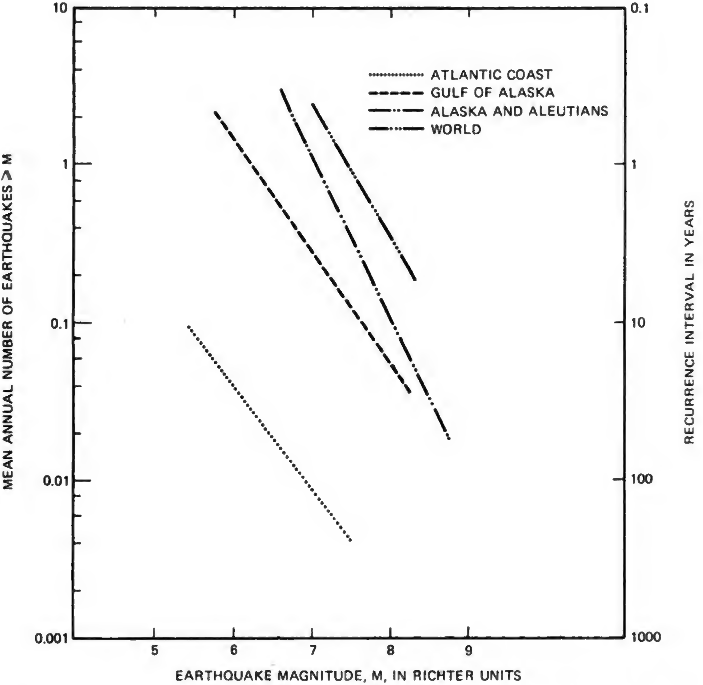
Tsunamis—seismic sea waves—are long-period, high-intensity ocean waves generated by large-scale, short-duration movement of the sea floor. Nearly all tsunamis are associated with large submarine earthquakes of Richter magnitude 6.5 or greater. Tsunamis are characterized by great speeds of propagation (up to 600 miles per hour), long periods (varying from a few minutes to a few hours, but generally 10 to 60 minutes), and low observable amplitudes in the open sea. Upon entering shallow water along an exposed coast, often thousands of miles from the source, a tsunami may reach a height of 100 feet and cause considerable damage and loss of life.

Tsunamis are generated locally or can result from remote disturbances. The impact of a single occurrence may be felt thousands of miles away. For example, the 1960 tsunami which began in Chile and killed hundreds there, reached Japan 24 hours later, killing 200 persons and destroying 5,000 structures and 75,000 boats. [2]

There are no recorded instances of remotely generated tsunamis occurring along the Atlantic coast. Should a tsunami be generated in Europe, for example, warning time is sufficient to take safety measures. The absence of local tsunamis is a function of earthquake intensity. An earthquake of 7 Richter—the largest recorded in the Atlantic—would probably generate a seismic sea wave no more than 6 feet high. In fact, the Grand Banks earthquake did produce a small tsunami. On the other hand, an earthquake of 8 Richter could cause 30-foot waves and significant damage.

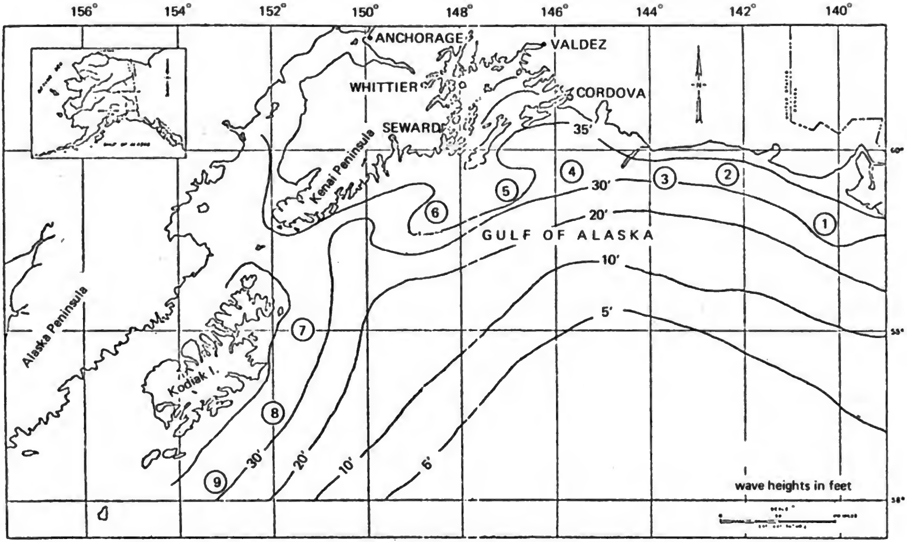
Destructive local tsunamis have occurred in the Gulf of Alaska ports of Valdez, Cordova, Whittier, Seward, Kodiak, and Yakutat in this century. The 1964 Prince

William Sound earthquake produced waves over 30 feet high. According to Tetra Tech calculations, tsunami wave heights of 35 feet are conceivable near the hypothetical drilling sites in the Gulf of Alaska (see Figure 5-4). The long wave length of a tsunami will produce strong upward forces on buoyant structures attached



Source: Tetra Tech, Inc., 1973, "The Effect of Natural Phenomena on OCS Gas and Oil Development," prepared for the Council on Environmental Quality under contract No. EQ4AC010.

Figure 5-3. Frequency and Magnitude of Earthquakes on the Atlantic Coast and in the Gulf of Alaska, Alaska and Aleutians, and the World



Source: Tetra Tech, Incorporated, 1973, "The Probabilities and Potential Releases of Oil from Natural Phenomena," prepared for the Council on Environmental Quality under contract No. EQ4AC010.

Figure 5-4. Tsunami Height Distribution in the Gulf of Alaska

to the bottom, such as underwater storage tanks. Platforms seem less likely to be threatened.

As a tsunami moves from deep water into shallower water and approaches the shoreline, the nature of the water motion changes and a wall of moving water is formed. The forces developed by this rushing wall of water can cause serious damage to shoreline structures and ships moored alongside wharves and piers.

Calculations for the Seward area show that 26-foot waves would be generated from a seismic event near Seward and 10-foot waves would result from an event 150 miles away in the eastern Gulf (see Figure 5-5). These calculations ignore the effects of harbors. Depending upon a harbor's geometry, waves reflected from the shoreline may interact with the incoming wave to produce either higher-amplitude waves or lower-amplitude waves. Other factors affecting the magnitude of a tsunami are its length, envelope, and direction of approach as well as water depth variations nearshore. When these factors act in concert, the increase in wave height may be large.

SUMMARY AND CONCLUSIONS

Attention to natural phenomena is critical to OCS structure design and to assessment of site acceptability. Storms may be more severe in parts of the

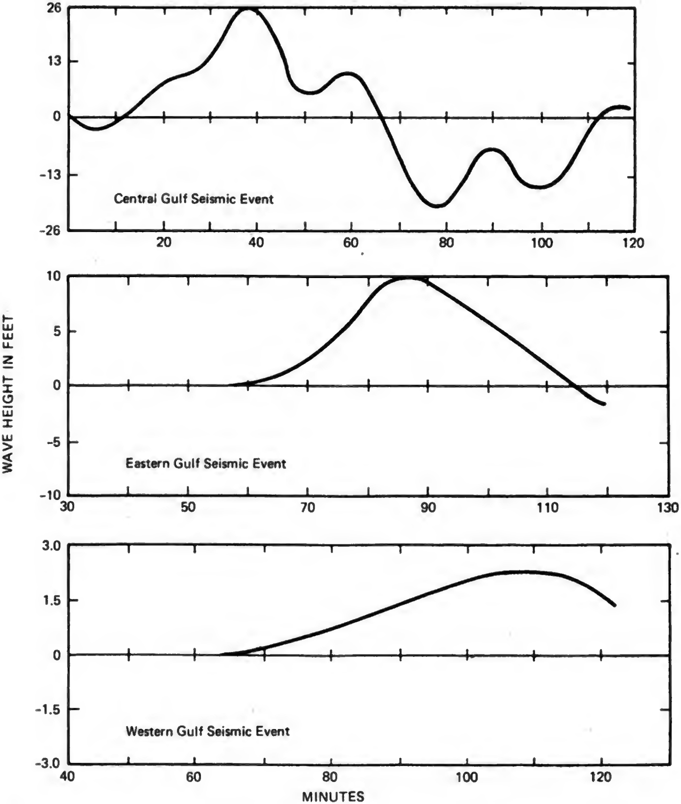
TABLE 5-2

Effects of Natural Phenomena on Elements of Oil Production

Element		Natural phenomena				
		Severe storm	Earthquake		Tsunami	Volume of oil at risk per event
			Vibration	Soil stability		
Platform		Slight[1]	Slight[2]	Slight[3]	None	500-1500 barrels per well per day
Pipeline		None	None	Serious[4]	None	10,000 barrels or more
Storage	Ashore	Slight[5]	Slight[6]	Slight[3]	None	Up to 1,000,000 barrels or more[7]
	Afloat	Moderate	None	Slight[8]	None[9]	200,000 to 1,000,000 barrels
	Underwater	Moderate	Serious	Serious	Serious	100,000 barrels or more
Underway		Slight[10]	None	None	None	
Moored-SPM		Slight[11]	None	Slight[11]	None[11]	500,000 to 2,000,000 barrels
Fixed berth		Slight	None	None	Serious	

[1] Storm forces in the Atlantic and Alaska are comparable to those in the North Sea.
[2] Provided earthquake resistant design features are used.
[3] Provided careful soil analysis program is followed.
[4] It may be possible to reduce threat by line routing over less susceptible areas.
[5] Provided tanks are sited away from flood-prone areas.
[6] Provided free surface effect is reduced.
[7] Dikes give protection against damaging oil spill.
[8] Assumes control can be regained before floating storage grounds or capsizes.
[9] Provided floating storage is moored in deep water.
[10] Assumes regular inspections and prudent seamanship.
[11] Assumes ship control is regained before grounding.

Source: Tetra Tech, Inc., 1973, "The Effect of Natural Phenomena on OCS Gas and Oil Development," prepared for the Council on Environmental Quality under contract No. EQ4AC010.



Source: Tetra Tech, Inc., 1973, "The Effect of Natural Phenomena on OCS Gas and Oil Development," prepared for the Council on Environmental Quality under contract No. EQ4AC010.

Figure 5-5. Tsunami Height Calculations for Seward from Hypothetical Seismic Events, Excluding Harbor Effects

Atlantic than in the Gulf of Alaska or the North Sea, and weather conditions in the Gulf of Alaska are generally worse than in the Atlantic. Icing does not appear a major problem in the Atlantic, but it could be severe in the Gulf. Earthquakes and tsunamis are serious problems in the Gulf of Alaska.

Table 5-2 summarizes the effects of natural phenomena on elements of the oil production system and the volume of oil that could be spilled by each event. Underwater oil storage would present a serious threat to the environment because failures caused by severe storms, earthquake vibrations, and tsunamis could release large volumes of oil—up to 1 million barrels; in the Gulf of Alaska, earthquake occurrence calculations indicate that oil would spill from such storage sometime during the life of a field. Onshore storage has a much smaller probability of failure, assuming that dikes are used to retain oil from tank failures. The integrity of the dikes is highly dependent on the quality of soil foundation and suitability of the site.

Earthquakes seriously threaten platforms. In addition to spilling oil, platform failures risk lives. Designs must incorporate vibration resistance, and platforms must be carefully located to avoid earthquake-induced soil instability. Structure vibration is most intense directly on the fault; however, within about 4 miles of the fault the forces on a structure are roughly equivalent (see the Chapter 8 discussion of seismic effects and platform design).

Tankers moored at fixed berths are also endangered, especially by tsunamis. In the 1964 earthquake, the 10,000-ton freighter CHENA broke its mooring in the port of Valdez when the land slumped at the shoreline. The vessel was carried several hundred yards away from the pier by the outrushing water and then back onto the shore flats by the reflected wave. Tankers moored to a floating facility in deep water risk less damage from tsunamis than if moored at a fixed berth near shore. In general, however, tsunamis may be serious hazards to tankers and could result in large oil spills. Without careful study and testing at individual harbors, the impacts in Gulf of Alaska harbors cannot be predicted.

Pipelines are least sensitive to storms and tsunamis, although major ground faulting or soil instability during an earthquake could cause major damage and result in spills of 10,000 barrels or more.

The Gulf of Alaska is more prone to frequent and severe earthquakes, tsunamis, ice, and storms than is the Atlantic. The Council believes that oil and gas development in these hostile conditions increases the risk of environmental damage over that in the Atlantic OCS. In both areas, however, the petroleum industry will have to design for more hostile environments than those in which they have been working in the Gulf of Mexico.

REFERENCES

1. Tetra Tech, Inc., 1974, "The Effect of Natural Phenomena on OCS Gas and Oil Development," prepared for the Council on Environmental Quality under contract No. EQ4AC010.

2. Li-San Hwang and David Divoky, "Tsunamis," *Underwater Journal*, Vol. 3, No. 5, October 1971, p. 207.

Chapter 6. Offshore Effects of OCS Development

Production from offshore oil wells has grown 350-fold in the years since the first Federal lease sale in 1954. During this period, management, procedures, and regulations of offshore operations have improved—and continue to do so. Yet in the minds of most people, the offshore industry is associated with Santa Barbara and oil spills. During the Council's public hearings, citizens expressed skepticism about prevention of oil spills and other threats to the environment.

Each phase of offshore development has environmental impacts. An environment is changed by the discharge of small amounts of oil as part of routine operations, and it is changed by the massive oil spill. It is changed by placing structures on the ocean floor, by constructing and laying pipelines, by releasing the drilling muds and cuttings, by generating wastes. Indeed, it is changed by man's presence day to day.

This chapter looks at the changes that occur in the marine environment as a direct result of OCS operations. What happens onshore is described in Chapter 7.

MOVEMENT OF OIL SPILLS

Oil can move great distances in water. As it moves, it changes chemically. Oil is transported by the ocean currents, surface winds, and surface waves. It may ultimately drift out to sea or come ashore. It may come into contact with various marine organisms.

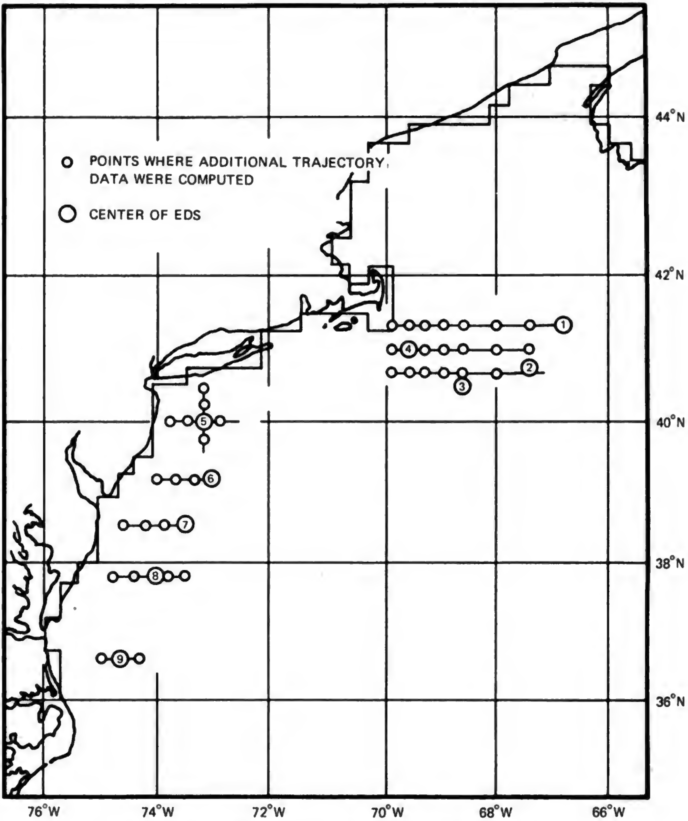
Freshly spilled oil is considerably different than weathered oil—i.e., oil that has been in the water for some time and has given up many of its volatile and soluble components. Nevertheless, weathered oil may damage birds and marine organisms and may remain in the sediments.

Development of offshore petroleum must be evaluated in terms of possible effects of the coastal and offshore regions as well as onshore. Valuable wetlands, beaches, and tidal flats can be physically and biologically changed by the presence of oil. Residents of the areas may suffer economic, social, and psychological harm from the possibility and reality of accumulated oil. The value of preserving recreational, business, and ecologically productive areas must be acknowledged in the development decision.

There are a number of uncertainties associated with assessing the impacts of oil spills—location of the spill, size, time of year, winds, and currents. All affect the movement and biologic effects of oil. To address these questions, the Council contracted with the Massachusetts Institute of Technology to analyze the probability of oil coming ashore from several spill locations, where it would come ashore, and how long it would take to reach shore. M.I.T. used computer modeling techniques based on those developed in its Georges Bank study. [1] The model has shown reasonably good agreement with observed drift bottle statistics. It is described in greater detail in the M.I.T. report to CEQ. [2] Data inputs for the models were provided by the National Oceanic and Atmospheric Administration, the Virginia Institute of Marine Sciences, and the University of Alaska.

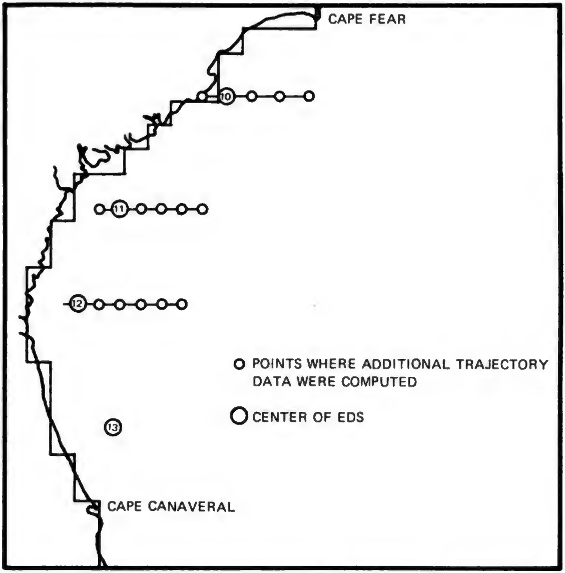
Offshore Spills

M.I.T. computed the trajectories of offshore oil spills occurring at various sites in each major potential oil and gas production area—Georges Bank, Baltimore Canyon Trough, Georgia Embayment, and Gulf of Alaska. Hypothetical spills were launched at the center



Source: The Massachusetts Institute of Technology Department of Ocean Engineering.

Figure 6-1. Points in the Baltimore Canyon Trough/Georges Bank Region for Which Detailed Trajectories Were Calculated



[1] In this trajectory analysis EDS 13 and 14 as defined in Chapter 2 were combined and are designated EDS 13.

Source: The Massachusetts Institute of Technology Department of Ocean Engineering.

Figure 6-2. Points in the Georgia Embayment Region for Which Detailed Trajectories Were Calculated[1]

of each oil and gas resource area and to test the sensitivity of results to specific spill location, at various points from the coast (see Figures 6–1 to 6–3). The trajectory analysis covers the probability of a spill reaching the shore, the average time to reach shore, and the minimum time to reach shore.* It should be recognized that these calculations assume that no containment measures are taken; in some cases, containment and cleanup equipment may be deployed soon enough to reduce the impact of the spill. Drift bottle launch and recovery records obtained from NOAA were used to calibrate and correlate the results of the computer simulations with observed movements of oil.†

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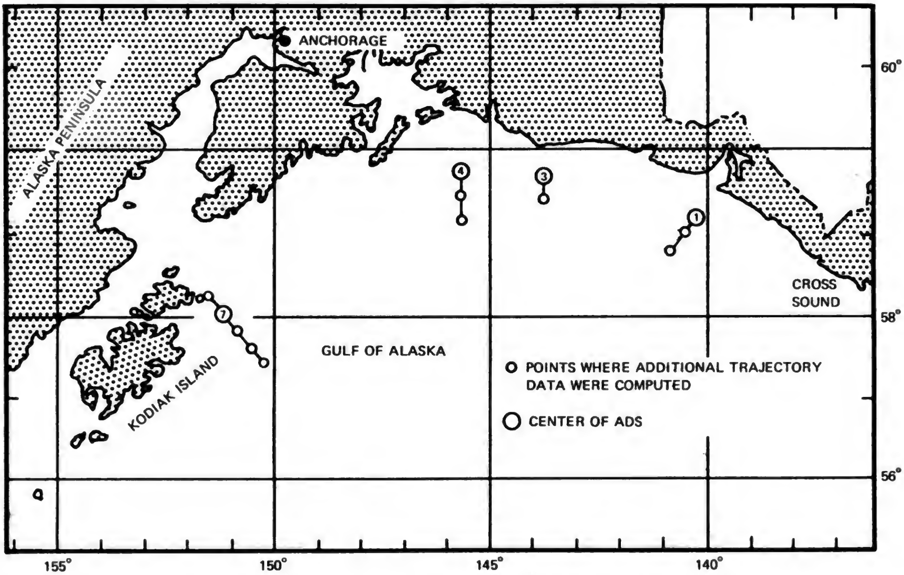
*The M.I.T. model takes into account oil reaching shore within 150 days. Oil that does not reach shore within that time is defined as not reaching shore at all.

†A drift bottle is essentially a well-corked bottle that contains instructions for mailing an enclosed postcard to the investigator conducting the experiment. The bottles are launched at various locations and under different conditions. Although their drift and recovery provide helpful information about currents and wind patterns, there is no proof that drift bottle data duplicate the behavior of real oil spills.



Source: Massachusetts Institute of Technology Department of Ocean Engineering.

Figure 6-3. Points in the Gulf of Alaska Region for Which Detailed Trajectories Were Calculated

TABLE 6-1

Probabilities of Oil Spills Coming Ashore from Hypothetical Spill Sites in the Atlantic Ocean

Shore point	Season[1]	Distance from shore						Center of EDS
		10 miles east	25 miles east	50 miles east	75 miles east	100 miles east	125 miles east	
Nantucket	Spring	65%	45%	30%	25%	20%	20%	15% (EDS 1)
	Autumn	30	10	5	0-5	0-5	Near 0	Near 0 (EDS 1)
Nantucket Shoals	Spring	50	50	35	30	20	20	20 (EDS 2) 35 (EDS 3)
	Winter	5	5	5	5	5	4-5	Near 0 (EDS 2) Near 0 (EDS 3)
Davis South Shoal	Spring	55	50	35	25	20	–	50 (EDS 4)
	Winter	10	10	5	5	5	–	5-10 (EDS 4)
Great South Bay[2] (Long Island)	Summer	95-100	75	10	–	–	–	10 (EDS 5)
	Winter	30	15	Near 0	–	–	–	Near 0 (EDS 5)
Atlantic City	Spring	–	20	25	15	–	–	20 (EDS 6)
	Winter	–	0-5	0-5	0-5	–	–	0-5 (EDS 6)
Fenwick Island	Spring	–	15	20	20	–	–	20 (EDS 7)
	Winter	–	0-5	0-5	5	–	–	5 (EDS 7)
Chincoteague Inlet	Spring	–	5	15	25	–	–	20 (EDS 8)
	Autumn	–	0-5	0-5	0-5	–	–	0-5 (EDS 8)
Cape Henry, Va.	Spring	–	Near 0	Near 0	Near 0	–	–	Near 0 (EDS 9)
	Autumn	–	Near 0	Near 0	Near 0	–	–	Near 0 (EDS 9)
Cape Romain, S.C.	Spring	–	95	65	Near 0	–	–	95 (EDS 10)
	Autumn	–	Near 0	Near 0	Near 0	–	–	Near 0 (EDS 10)
Savannah	Spring	–	95-100	95	80	20	–	95-100 (EDS 11)
	Autumn	–	20	5	Near 0	Near 0	–	5 (EDS 11)
Fernandine Beach, Fla.	Spring	–	95	60	25	0-5	–	90 (EDS 12)
	Winter	–	15	10	Near 0	Near 0	–	15 (EDS 12)
Daytona Beach, Fla.	Summer	–	–	–	–	–	–	50 (EDS 13)
	Autumn	–	–	–	–	–	–	Near 0 (EDS 13)

– Computer model not run at this point.

[1] Two seasons are listed for each area. In the first season, oil spilled has the highest probability of reaching shore; in the second season, oil spilled has the lowest probability. Probabilities are intermediate in the unlisted seasons.

[2] The estimates for Great South Bay are distances south of the bay rather than east.

Source: Massachusetts Institute of Technology Department of Ocean Engineering.

Table 6-1 summarizes the probabilities of spilled oil coming ashore on the Atlantic coast. Results are reported for the center of the hypothetical drilling sites and at locations 10, 25, 50, 75, 100, and 125 miles from shore on an east-west traverse drawn through each site (with the exception of EDS 5 for which the traverse was drawn north-south through the site). Distance from shore is important because oil may well be produced at sites other than the hypothetical sites indicated in the study and because oil may be spilled from pipelines or tankers away from the drilling sites. The results are in terms of the percentage of the time that a spill would beach during the "best" and the "worst" seasons. At EDS 1, for example, which is located about 140 miles east of Nantucket, there is a 15 percent chance of a spring spill coming ashore and a near zero probability of an autumn spill reaching shore. For all sites, spring and summer tend to be the "worst." This seasonal dependence could be important to the recreational and tourist businesses of Cape Cod, Long Island, and New Jersey. If, as indicated, oil spills are more likely to come ashore during the prime vacation season, the economic and social effects may be greater than for the winter months. Sensitivity to

TABLE 6-2

Summary of Trajectory Behavior EDS 4, Spring

Impact region	Percentage	Average time at sea	Minimum time at sea
		(days)	
Remained in area	15.00		
Buzzards Bay to Rhode Island	6.00	79	20
Cape Cod and Islands	45.00	51	7
North Shore Massachusetts	0.00		
New Hampshire/Maine Coast	0.00		
Bay of Fundy	0.00		
Possible Impact Long Island	6.50	66	37
Nova Scotia East Shore	0.00		
Out to Sea Northeast to East of Georges Bank	0.00		
Out to Sea East to South of Georges Bank	0.00		
Out to Sea South to West of Georges Bank	25.00	59	25

Source: Massachusetts Institute of Technology, "Oil Spill Trajectory Studies for Atlantic Coast and Gulf of Alaska," *Primary, Physical Impacts of Offshore Petroleum Developments*, prepared for the Council on Environmental Quality under contract No. EQC330 (Cambridge: Massachusetts Institute of Technology, 1974), Report No. MITSG 74-20.

distance from shore appears significant within 50 miles of the coast and less significant beyond that. In every season except spring, spills over 100 miles from shore would reach the coast less than 10 percent of the time.

Georges Bank. For the Georges Bank area the probability of oil spills coming ashore from the four drilling site centers is fairly low. An accidental spill at EDS 1 appears to have the least risk of coming ashore at any point—it is less than 2 percent in summer and autumn, 4 percent in winter, and about 15 percent in spring. EDS 4 presents the greatest threat, with oil reaching shore about 50 percent of the time in spring. These results match intuitive judgment, for oil from the hypothetical drilling site nearest shore has much higher probabilities of beaching than oil from the most distant site.

The average times for a spill from the Georges Bank sites to reach shore range within 40 and 129 days. Most oil spills at the Georges Bank sites are likely to come ashore near Cape Cod (see Table 6-2). For example, 11 percent of spring oil spills from EDS 1 would come ashore near Nantucket Island. The average time is 104 days and the minimum is 43 days. There appears little likelihood that northern New England or Nova Scotia would be affected by spills at any of the hypothetical Georges Bank drilling sites.

Baltimore Canyon Trough. Oil spills from EDS 5, south of Long Island, would reach shore about 10 percent of the time in spring and summer, but if they occurred north of EDS 5, the probabilities would rise dramatically. For example, a summer oil spill 15 miles north of EDS 5 (30 miles south of Great South Bay) could reach the coast as often as 65 percent of the time, and a spill 30 miles north of EDS 5 (15 miles south of Great South Bay) would almost certainly reach shore during the summer. On the other hand, spills farther from shore or south of EDS 5 show only slight chances of coming ashore. The highest probability of spills from EDS 6, 7, and 8 reaching shore is about 25 percent in the spring. Varying the distance from shore does not significantly change the probabilities. Based on the model predictions, any spill from EDS 9, regardless of the season, has almost no chance of reaching shore. These conclusions for EDS 9 are somewhat tentative, however, because of a difference between the drift bottle statistics and the model's predictions.

Spill beaching probabilities from the Baltimore Canyon sites, like the Georges Bank, are a function of the season. That summer and spring present the greatest probabilities of oil coming ashore is especially important because spills from EDS 5 and 6 could affect

TABLE 6-3

Summary of Trajectory Behavior EDS 5, Summer

Impact region	Percentage	Average time at sea	Minimum time at sea
		(days)	
Remained in area	53.00	150	
Virginia-North Carolina Coast	0.00		
Chesapeake Bay Entrance Region	0.00		
Northern Virginia Coast	0.00		
Maryland Atlantic Ocean Coast	0.00		
Delaware Coast	0.00		
Delaware Bay Entrance Region	0.00		
Southern New Jersey Coast	0.00		
Barnegat Bay Region, N.J.	1.00	13	10
Northern New Jersey Coast	4.00	11	8
New York Harbor Entrance Region	0.00		
Western Long Island, N.Y.	1.50	6	6
Middle and Eastern Long Island, N.Y.	0.00		
Long Island Sound Entrance Region	0.00		
Connecticut Coast	0.00		
Rhode Island Coast	0.00		
Narragansett Bay Entrance Region	0.00		
Southern Massachusetts Coast	0.00		
Buzzards Bay Region	0.00		
Martha's Vineyard Island, Mass.	0.00		
South Coast of Cape Cod	0.00		
Nantucket Island, Mass.	0.00		
Northern Ocean Boundary	0.00		
Eastern Ocean Boundary	37.00	132	104
Southern Ocean Boundary	3.50	60	46

Source: Massachusetts Institute of Technology, "Oil Spill Trajectory Studies for Atlantic Coast and Gulf of Alaska," *Primary, Physical Impacts of Offshore Petroleum Developments*, prepared for the Council on Environmental Quality under contract No. EQC330 (Cambridge: Massachusetts Institute of Technology, 1974), Report No. MITSG 74-20.

the recreation-intensive Long Island and New Jersey coasts. A summer oil spill at EDS 5 has a 4 percent chance of reaching the northern New Jersey coast; the minimum time to shore is 8 days and the average time is 11 days (see Table 6–3). A summer spill 15 miles north of EDS 5 has a 43 percent chance of reaching the western Long Island shore, with a minimum time of 3 days.

Spills from the middle and lower Baltimore Canyon (EDS 7 and 8) could come ashore in Maryland, Delaware, New Jersey, or Long Island. Beaching time varies widely, depending upon site and season. For EDS 6, the minimum time to shore in spring is 61 days; 12 percent of the spring spills will hit middle and eastern Long Island, and 9 percent will hit western Long Island. In summer the probability drops to about 2 percent for all of Long Island. For EDS 8, minimum time to shore in the spring is 54 days; 16 percent of all spills will reach Long Island.

Southeast Georgia Embayment. Spills reaching shore from the Georgia Embayment sites (EDS 10 to 12) appear very sensitive to distance from shore (see Table 6–1). Probabilities drop markedly as the distance from shore increases. Spills nearer shore (within 25 miles) have a high probability of coming ashore—at the sample drilling sites, spring and summer probabilities are over 90 percent. Even 50 miles from the coast, chances are higher than 50 percent that a spring or summer spill will reach the coast. Most summer spills from EDS 12 would come ashore near St. Augustine, Fla., or southeastern Georgia. Spills at EDS 10 would beach at Cape Romain or elsewhere in South Carolina.

Beaching time is generally shorter for the Georgia

TABLE 6-4

Probabilities of Oil Spills Coming Ashore from Hypothetical Spill Sites in the Gulf of Alaska

Direction	Season[1]	Distance from shore					Center of ADS
		15 miles	30 miles	45 miles	60 miles	75 miles	
Southwesterly traverse through ADS 1	Summer	–	90%	85%	80%	–	95%
	Winter	–	35	20	10	–	40
ADS 2	Summer						95-100
	Winter						75
Southerly traverse through ADS 3	Summer	–	95	90	–	–	95-100
	Winter	–	45	25	–	–	55
Southerly traverse through ADS 4	Summer	95-100	95-100	90	80	–	95-100
	Winter	55	45	30	20	–	55
ADS 5	Summer						95
	Winter						60
ADS 6	Summer						95-100
	Winter						60
Southeasterly traverse through ADS 7	Summer	75	45	10	5	Near 0	45
	Winter	10	5	Near 0	Near 0	Near 0	5
ADS 8	Summer						5
	Winter						0-5
ADS 9	Summer						5-10
	Winter						Near 0

– Computer model not run at this point.

[1] Two seasons are listed for each area; in the first season, oil spilled has the highest probability of reaching shore; in the second season, oil spilled has the lowest probability; probabilities are intermediate in the unlisted seasons.

Source: The Massachusetts Institute of Technology Department of Ocean Engineering.

Embayment sites than for other areas. The minimum time to shore for a spill in the spring at EDS 10 is 10 days; at EDS 12 the minimum is 21 days.

Gulf of Alaska. As in the Georges Bank region, wind behavior in the Gulf of Alaska differs considerably from spring and summer to fall and winter. The predominant wind direction is offshore, but the winds' change in spring and summer sharply increases the chances that an oil spill will reach shore. Table 6–4 summarizes probabilities for the "best" and "worst" seasons. Spills at the Gulf of Alaska sites generally have a high probability of coming ashore someplace in Alaska. Spills at western Gulf sites have about a 10 percent chance of reaching shore except in summer. The eastern Gulf sites (ADS 1 to 4) are less sensitive to distance from shore than the Atlantic coast sites because the presumed flow of the Alaska current tends to transport the spills along the coast for a great distance with little net offshore motion. Thus they have sufficient time to travel northward to the coast. In the western portion of the Gulf of Alaska, the same current would tend to move the spills southward and away from land, allowing some fraction to miss Kodiak and the Tremki Islands. Summer spills from ADS 4 would most likely reach Montague Island and the Hinchinbrook Island-Katalla area (see Table 6–5).

The minimum beaching times from spill sites in the Gulf of Alaska range from 3 days (from ADS 3) to 39 days (from ADS 1), and the average is 20 to 30 days.

Nearshore Spills

OCS operations can cause oil spills nearshore as well as at production sites. They occur during use of tankers, barges, and pipelines. Because the oil from nearshore spills reaches shore in a shorter time, it weathers less and thus can be more toxic to estuarine life than oil spilled some distance offshore. M.I.T. investigated these spills in three prototype areas: Buzzards Bay, Delaware Bay, and Charleston Harbor. The model used is similar to the offshore trajectory

TABLE 6-5

Summary of Trajectory Behavior ADS 4, Summer

Impact region	Percentage	Average time at sea	Minimum time at sea
		(days)	
Remained in area	0.00		
Afognak Island	0.00		
North Kodiak Island	0.00		
South Kodiak Island	0.00		
Trinity Islands	0.00		
Cape Igvak-Amber Bay	0.00		
Cape Douglas-Cape Igvak	0.00		
West Shore of Cook Inlet	0.00		
East Shore of Cook Inlet	0.00		
Southern Kenai Peninsula	3.50	43	29
Seward	1.50	36	24
Montague Island	48.00	28	11
Western Prince William Sound	0.50	21	22
Eastern Prince William Sound	1.00	49	37
Hincinbrook Island-Katalla	45.50	21	6
Cape St. Elias-Icy Cape	0.00		
Pt. Riou-Yakutat	0.00		
Yakutat-Cape Fairweather	0.00		
Cape Fairweather-Chichagof Island	0.00		
Nearshore, Southeast Ocean Boundary	0.00		
Southeast Ocean Boundary	0.00		
Southern Portion, Southeast Ocean Boundary	0.00		
Southern Portion, Southwest Ocean Boundary	0.00		
Southwest Ocean Boundary	0.00		
Nearshore, Southwest Ocean Boundary	0.00		

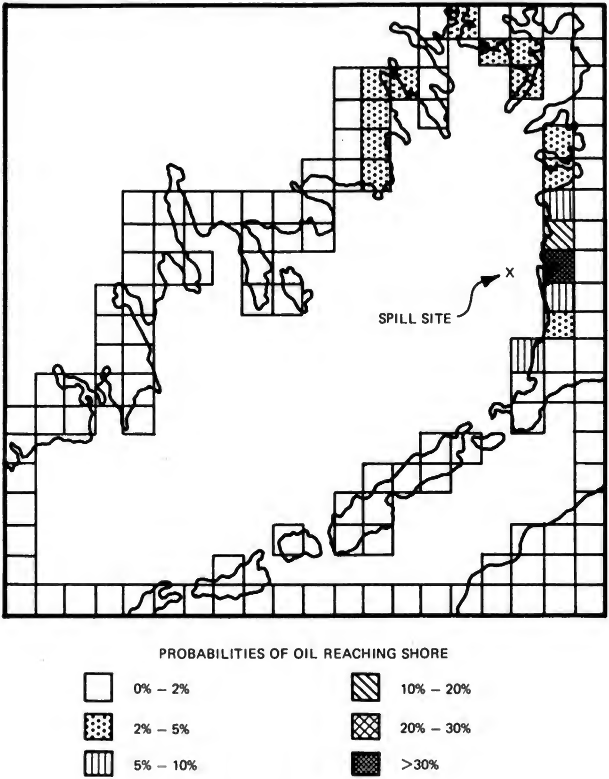
Source: Massachusetts Institute of Technology, "Oil Spill Trajectory Studies for Atlantic Coast and Gulf of Alaska," *Primary, Physical Impacts of Offshore Petroleum Developments*, prepared for the Council on Environmental Quality under contract No. EQC330 (Cambridge: Massachusetts Institute of Technology, 1974), Report No. MITSG 74-20.

models but also includes tidal movements. The analysis focused on the initial impact on a given shore area and the average time to shore for the initial impact.

Two spill sites were analyzed in the Buzzards Bay area—West Falmouth and the New Bedford channel entrance. A spill near West Falmouth would have a strong likelihood of coming ashore in the immediate area. The minimum time to shore in all seasons would be 2 hours or less and the average time would be 6 to 13 hours. Between 35 and 65 percent of West Falmouth spills would reach shore within 10 hours, and 75 to 90 percent would come ashore within 30 hours. Regardless of season, 95 percent of all spills would come ashore within 4 days (see Figure 6–4). A typical spill is described in a later section on Oil and the Physical Environment. A winter spill at the entrance of the New Bedford channel would have a more diffuse impact than a spill at West Falmouth (see Figure 6–5). Naushon Island, Pasque Island, and the area from Woods Hole to West Falmouth would be the areas most likely impacted; times to shore of less than 30 hours are common, with 85 percent of spills coming ashore within 40 hours, 95 percent within 60 hours, and 100 percent in 105 hours in winter.

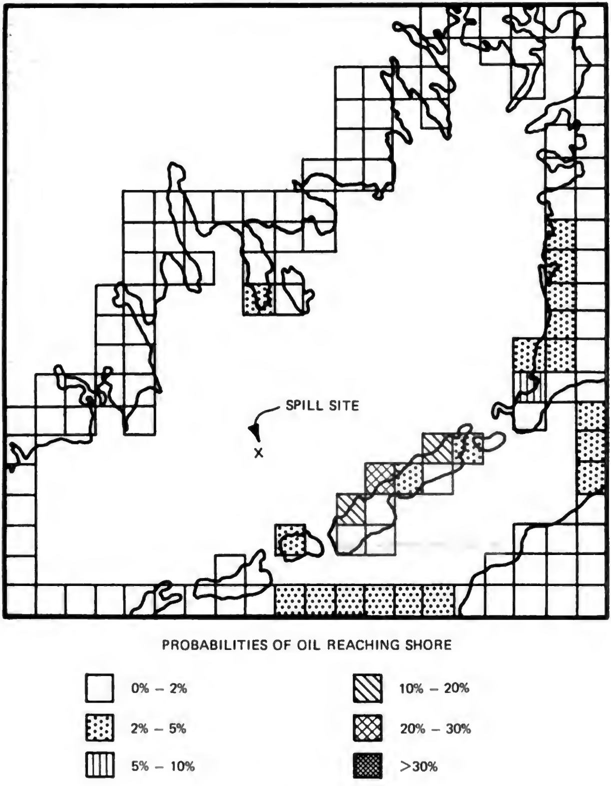
The trajectories of spills at a central Delaware Bay site vary considerably, depending upon the season. Winter spills will primarily affect the southeast coast of the bay, and summer spills will reach the northeast and northwest (see Figure 6–6 and 6–7). Beaching times are longer than for Buzzards Bay, with 50 percent of the spills reaching shore within 75 hours. Beaching times average about 100 hours, with little seasonal variation.

Spills occurring at the mouth of Delaware Bay



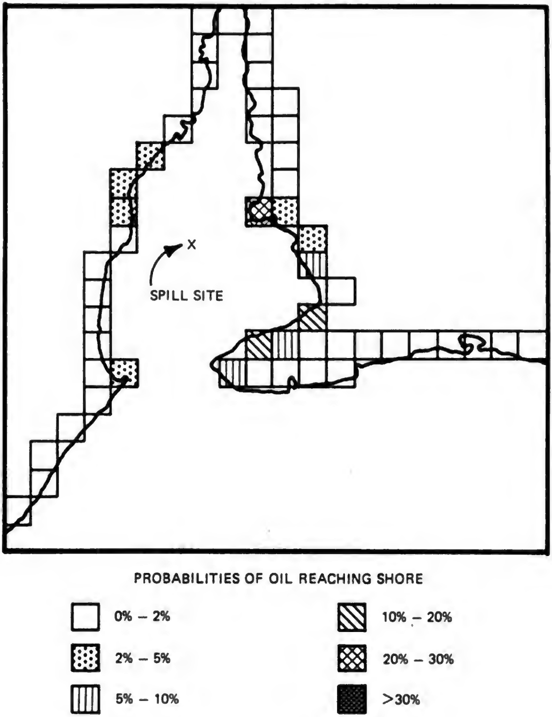
Source: The Massachusetts Institute of Technology Department of Ocean Engineering.

Figure 6-4. Buzzards Bay Impact Areas for the West Falmouth Spill Site, Winter



Source: The Massachusetts Institute of Technology Department of Ocean Engineering.

Figure 6-5. Buzzards Bay Impact Areas for the New Bedford Channel Entrance Spill Site, Winter

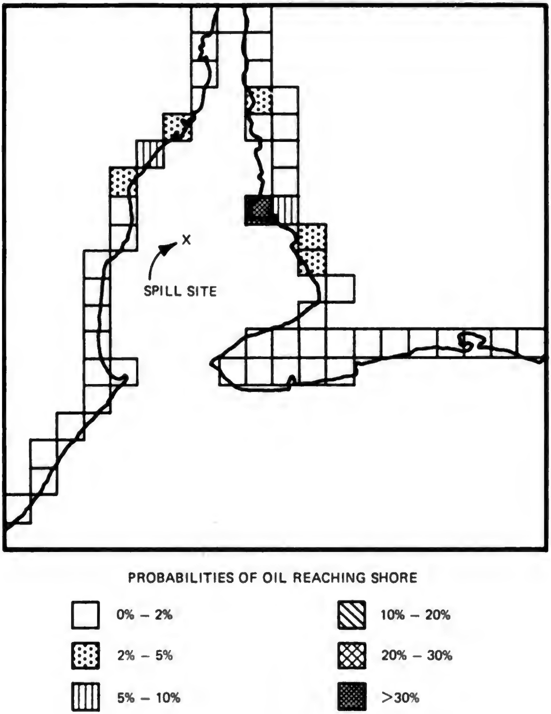


Source: The Massachusetts Institute of Technology Department of Ocean Engineering.

Figure 6-6. Delaware Bay Impact Areas for the Upper Bay Spill Site, Winter

demonstrate strong seasonal differences. In winter the direction is south or out to sea, and in summer movement is toward the eastern shore. The percentage of spills coming ashore is slightly lower than for the central bay, except in winter. For all seasons, 50 percent of the spills reach shore within 100 hours.

Charleston Harbor is considerably smaller than either Buzzards Bay or Delaware Bay. Spills in the harbor would come ashore more quickly than in the other areas. The average times to areas with a high



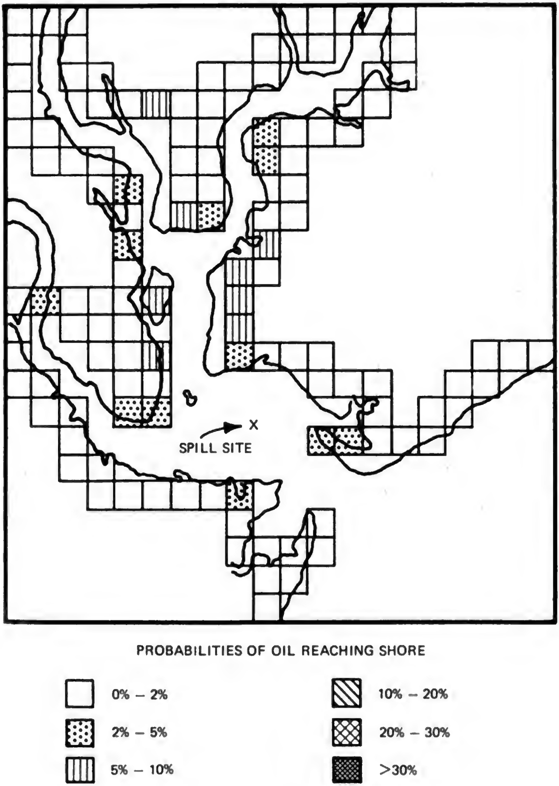
Source: The Massachusetts Institute of Technology Department of Ocean Engineering.

Figure 6-7. Delaware Bay Impact Areas for the Upper Bay Spill Site, Summer

probability of spilled oil reaching them (see Figure 6–8) are usually less than 10 hours and often under 6 hours. Minimum time is sometimes as short as 2 hours. Oil spilled will reach almost any area that it is going to within 30 hours, and 75 percent of the spills will do so within 10 hours.

ENVIRONMENTAL INVENTORY

The preceding discussion focuses on where and how



Source: The Massachusetts Institute of Technology Department of Ocean Engineering.

Figure 6-8. Charleston Harbor Impact Areas for the Central Harbor Spill Site, Winter

fast oil spilled at selected sites in the Atlantic and the Gulf of Alaska may be expected to move. Another aspect of oil spills is the changes that they make en-route and after they reach shore. The changes depend not only upon the oil but also upon the biological characteristics of the marine and coastal areas affected.

It is beyond the scope of this report to detail the environment and resources of the Atlantic and Alaskan outer continental shelves. These vast expanses include widely diverse marine and coastal environments.

The function of the OCS environmental inventory is to describe the OCS environment in a way that will serve as a basis for indicating how OCS development affects important living resources. To do the job, M.I.T. considered the OCS environment as a hierarchy of subsystems: biogeographical regions, habitats, populations, and individual organisms.

A habitat is here defined as a subsystem that can be categorized on the basis of similar physical and/or chemical characteristics (e.g., sediment type, salinity) and which contains an identifiable, generally characteristic assemblage of species (e.g., rocky shore, salt marsh, and pelagic areas).

Biogeographical regions may be defined largely according to temperature zones. In this study four biogeographical regions are defined: (1) the Bay of Fundy to Cape Cod, (2) Cape Cod to Sandy Hook, (3) Sandy Hook to Cape Canaveral, and (4) the Gulf of Alaska. They roughly correspond, respectively, to portions of Hedgepeth's Shallow Water Biotic Provinces: (1) the southern third of the American, (2) the northern tip of the Virginian, (3) the remainder (most) of the Virginian, and (4) the middle portion of the Aleutian Biotic Province. [3]

For most analyses, M.I.T. assumed that each type of habitat is physically and biologically similar within a given biogeographical region. For each habitat type in each biogeographical region, certain species were selected for analysis. They were selected because of their importance for ecological, commercial, or recreational reasons or because of scientific interest and the availability of data.

Overview of the OCS Regions

The OCS from the Bay of Fundy to Cape Cod roughly coincides with the Gulf of Maine and the Georges Bank. Here the coast generally is moderately to heavily indented, with a mixture of shoal grounds, occasional islands, rocky shores, and many estuaries.

The New England shelf, bounded in part by Georges Bank, has irregular bottom contours, featuring a number of fairly complex basins that are 200 to 300 meters deep. Most bottom sediments are high in silt and clay, with scattered areas of gravel and stones.

Surface water circulation in the region consists mainly of a counterclockwise eddy that is especially pronounced in the spring. Nearshore circulation is much influenced by river outflows, the semidiurnal (twice daily) tides, irregular bottom contours, and winds. Bottom water circulation is predominantly shoreward. The Labrador Current—from along the Nova Scotia coast—brings cold water southward.

The relatively nutrient-rich waters of the region support a diverse and abundant assemblage of cold-water marine life. Economically the most important invertebrates are lobsters, northern shrimp, sea worms, and scallops. Except for shrimp, most of the commercial catch of these species is taken within the 12-mile limit.

Finfish of major commercial and recreational importance in these waters are cod, pollock, whiting, ocean perch, gray sole, Atlantic herring, groundfish, mackerel, haddock, winter flounder, striped bass, and the seriously depleted Atlantic salmon, which suffers from pollution of its spawning streams.

The two southern regions, from Cape Cod to Cape Canaveral, include most of the U.S. Atlantic coast. Here are coastal plains, sand beaches, sand barrier islands, salt marshes, and deep embayments, to name the major coastal features.

Inshore of the Baltimore Canyon Trough and the Florida-Hatteras slope, the continental shelf is relatively smooth, except for minor, often sandy ridges and often muddy troughs which generally run parallel to shore. The patchy bottom sediments are predominantly sand, gravel, and mud.

Tides are mostly semidiurnal, and tidal currents are moderate to weak along the coast. The dominant surface water flows are southerly, although there are local and seasonal exceptions. Bottom flows appear mostly onshore and/or southerly.

As was true of the colder north, there are many finfish and shellfish of sport and commercial importance among the warmer-water biota, including American lobster, surf clam, ocean quahog, blue crab, American oyster, scallop, the winter, summer, and yellowtail flounders, bluefin tuna, striped bass, bluefish, tautog, haddock, hake, pollock, menhaden, and mackerel. Many finfish species use nearshore waters as spawning and nursery areas. In addition, as with most aquatic systems, diverse planktonic and benthic organisms are critical to the food web.

Although not well studied, the Alaskan OCS unquestionably is rich in fish and wildlife resources.

Commercial fisheries contribute an important part of Alaska's tax revenues; until recently, more than half of the state's revenues were directly derived from fishing. Principal salmon fishing occurs in Prince William Sound, in Cook Inlet, and near the Copper River and Kodiak Island. Pink, chum, and sockeye salmon dominate, but chinook and coho salmon are also harvested. Alaska produces most of the pink salmon caught in North America. Over 200,000 metric tons of Pacific Ocean perch is harvested annually in the Gulf of Alaska, and other commercially important species are the flounder and Pacific halibut. The king crab is the principal commercial shellfish of the Alaskan Gulf. Although widely distributed, this species reaches maximum densities at depths ranging from 60 to 200 meters. Other important shellfish are the snow crab which are abundant at 100 to 300 meters. scallops, and several species of shrimp. The Gulf of Alaska shrimp fishery is thriving, having grown approximately fivefold in the last 5 years. In total weight, only the salmon harvest is larger than the annual shrimp harvest.

Twenty-three species of marine mammals have been seen in the Gulf of Alaska. Principal resident populations include the Steller sea lion, harbor seal, sea otter, Dall porpoise, and beluga. The sea otter seems to be recovering from the effects of excessive commercial fur hunting. Among the migrants are the northern fur seal, some whales, and the harbor porpoise. Rarely observed species include the walrus, beaked whales, and some dolphins.

Over 200 species of birds are known to visit or reside in the Gulf of Alaska. Most are primarily water or shore birds, and approximately 60 species are year round residents. Many ponds, river deltas, glacial plains, and coastal areas are their breeding grounds. The Gulf is a major flyway, and large numbers of diving ducks, mallards, mergansers, and Vancouver Canada geese winter in its estuaries. Many sea birds nest on cliffs along the shores, and some spend several months of the year at sea on unfrozen waters. The Copper River delta and Prince William Sound provide habitat for trumpeter swans, many species of ducks, and the world's population of dusky Canada geese.

Detailed Studies

The Council subcontracted with The Research Institute of the Gulf of Maine and the University of Rhode Island to provide information for the area from the Bay of Fundy to Sandy Hook, the Virginia Institute of Marine Sciences for Sandy Hook to Cape Canaveral, and the University of Alaska for the Gulf of Alaska. The information that these subcontractors provided M.I.T. was developed from available literature. No original research was undertaken. Although data are sparse on many topics, particularly for the Gulf of Alaska, the following information was sought for each of the species selected for analysis:

- Larval life type
- Fertility rates
- Natural mortality rates
- Growth rates
- Maximum local population densities
- Spawning area
- Spawning behavior
- Importance of chemical cues
- Population distribution
- Major food species
- Major parasites and/or major commensals*
- Major predators
- Major competitors.

Habitat descriptions are fairly complete for most Atlantic regions; they are identified in Table 6-6. There are large gaps in life history information about most species selected, and for one-half of them, information on fecundity, survival, and larval life is unavailable.

Information about Gulf of Alaska life is even more difficult to find. The University of Alaska was able to provide data for several areas, but they are by no means comprehensive. Most of the information concerns commercial fish and shellfish (see Table 6-7). This information does not completely describe an area's fauna because, for example, no commercial fishing has yet developed in the area.

EFFECTS OF OIL

How oil discharged into the marine environment affects it and the life within it is particularly controversial. Although studies, reviews, and conferences have addressed this general question, few consenses have been reached, especially regarding impacts on marine populations and communities.

Most studies have dealt either with lethal and sub-

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*Commensals are plants or animals which live in close association with organisms of different species.

TABLE 6-6

Types of Habitat Identified in Atlantic Regions

Habitat	Bay of Fundy to Cape Cod	Cape Cod to Sandy Hook	Sandy Hook to Cape Canaveral
Rocky shores	X	X	A
Shallow salt pond	X	X	A
Oyster-mussel reef	X	A	X
Sand beach/shore	X	X	X
Salt marsh	X	X	X
Worm-clam flat	X	X	X
Pelagic system	X	X	(1)
Offshore bottom	X	X	B
Grass bottom systems	C	C	X
Oligohaline system[1]	D	D	X
Medium salinity plankton system[1]	D	D	X
Coastal system[1]	D	D	X
Neutral embayments[1]	A	A	X

X – Identified.
A – Does not occur importantly in region.
B – Included in coastal system category.
C – Included in salt marsh category.
D – Included in pelagic category.

[1] Includes pelagic and benthic species. Differentiation of related habitats is based on salinity.

Source: The Massachusetts Institute of Technology Department of Civil Engineering.

lethal effects of oil on individual organisms or with postspill observations. Several critical reviews and literature surveys are available; yet there have been few attempts to synthesize and apply study results, available field data, and species life history information to qualitative and quantitative predictions of marine population and community impacts.

The situation is understandable. First of all, usually missing are prespill baseline data against which to compare postspill measurements. In addition, the analyst must deal with the many shortcomings of the data that are available–uncertainties about the field applicability of laboratory toxicity studies, lack of oil toxicity and life history information on most species, and the relatively primitive state of knowledge about energetics and dynamics of marine populations and communities, to say nothing of the magnitude, duration, and other parameters of potential oil spills. Because of these limitations, predictions are necessarily tentative and subject to error.

In spite of the difficulties, however, predicting impacts on marine populations and communities is a necessary part of this study. It is approached by considering two major phases: initial impacts and recovery.

Initial impacts are the rapid physical, chemical, and biological changes that result from oil spills. Recovery is the set of dynamic processes by which a system returns to ecological equilibrium. Physical, chemical, and biological recovery, as well as chronic and sublethal effects of oil, are a part of the oil spill impact analysis. The following subsections summarize the results of the M.I.T. analyses and other studies.

OIL AND THE PHYSICAL ENVIRONMENT

Crude petroleum is a mixture of hundreds of chemical compounds derived from biological matter that has accumulated in reservoirs and has been subjected to physical, chemical, and biological processes for millions of years. [4] The physical and chemical composition of petroleum varies greatly, depending upon where it is obtained. Toxicity of each type of oil depends substantially on the water-soluble and aromatic fractions of petroleum that it contains. [5] The volatile aromatics are considered the most toxic, [6] although other low-boiling hydrocarbons may also be toxic. [7]

Petroleum derivatives, the distillate fractions of crude oil–gas, gasoline, kerosene, light gas oil, heavy gas oil, and light lubricating oil–and blends of diesel fuel may also be toxic. Some distillates, such as No. 2 fuel oil and other petroleum derivatives, appear more toxic than crude oil because the distillates contain

TABLE 6-7

Available Information on Selected Species in the Gulf of Alaska

Species or common name	Distribution	Larval life-style	Fecundity	Mortality	Growth rate	Density	Chemical cues	Spawning area	Spawning season	Spawning behavior
Cancer magister (Dungeness Crab)	Inshore water 0-50 fathoms	First pelagic, then benthic	? (one case: 1.5×10^6 eggs/famale)	?	Several estimates available	? (Poor information, on a few commercial areas only)	?	? (Locations of commercial importance are known, but no complate survey of Gulf)	?	
Paralithodes camschatica (King Crab)	Approx. 80 fathoms	First pelagic, then benthic	50,000-400,000 eggs/female	?	Several estimates available	"	?	"	"	Fairly well known
Chionoeletes bairdi (Tanner Crab)	50-150 fathoms	First pelagic, then benthic	5,000-150,000 eggs/female	?	Several estimates available	"	?	"	? (Estimates range from January-September)	? (Partially known)
Pandalus spp. (Shrimp)	30-70 fathoms	Pelagic	600-3,400 eggs/female	?	?	"	None	"	Spring	?
Salmon (Coho, Chum, Pink, King, Red)	? (All along the coast and offshore Gulf waters)	Anadromous	?	?	? (Incomplete information on a *few* species)	?	*Important* in determining which river in which to breed	? (Run up hundreds of major and minor streams, but no complete survey of Gulf)	July-September	Fairly well known for most Salmon species
Demersal fish *Platychthys* sp. (Flounder) *Lepidopsetta* spp. (Rock Sole) *Gadus* spp. (Cod) *Raja* spp. (Skate) *Atheresthes* sp.	**0-50 fathoms** (All along the coast and offshore Gulf waters)	Pelagic	?	?	?	?	?	?	?	?
Birds Trumpeter Swan, Dusky Canada Goose	? (Coastal marshes in general)	**Not applicable**	? Low	?	?	?	?	? (Coastal marshes-not known more specifically)		?

Source: The Massachusetts Institute of Technology Department of Civil Engineering, 1974, "Atlantic/Alaskan OCS Petroleum Study: Primary Biological Effects," prepared for the Council on Environmental Quality under contract No. EQC330, using Arctic Environmental Information and Data Center, University of Alaska, data.

higher proportions of medium-boiling aromatics which have lower volatility and persist longer in the environment than other fractions. [8]

Persistence, or residence time, is the time that oil is detectable in the water, sediments, or biota. However, criteria and techniques for determining or estimating residence time vary considerably among investigators, and reported persistence can depend as much on the sensitivity of detection methods as on how long the oil in fact remains. Visual observation, the least sensitive, is employed most frequently. Although some studies are based on chemical analyses and bioassays, lack of uniform observation and detection methods confuses the question of oil persistence. Visual observations can provide useful data, but until methods are standardized, these gross data should be interpreted as underestimating oil persistence.

Petroleum in seawater is altered chemically by evaporation, dissolution, microbial action, chemical oxidation, and photochemical reactions—often collectively called weathering. How fast oil degrades is markedly influenced by light, temperature, nutrients and inorganic substances, winds, tides, currents, and waves. They all affect the microbial degradation, evaporation, dissolution, dispersal, and sedimentation processes. Degradation rates appear to vary with the composition of the oil. The more toxic fractions are generally less susceptible to microbial degradation. The heavy residuals that do not degrade may be deposited in sediments or they may float as tar lumps or tar balls.

Estimates of oil persistence are quite varied, even within a given habitat. Data are not standardized in format or type. Few studies are analytical, and few provide information on the hydrocarbons present in the sediments or local biota. Oil and its breakdown products may remain in sediments indeterminately. Or they may be churned up by turbulence to recontaminate a recovering area.

The persistence problem may be somewhat different in Alaska than in the Atlantic. The generally lower marine and coastal temperatures of Alaska will slow microbial action—not only because bacterial metabolism is slower but also because oil is more viscous at lower temperatures, which in turn causes thicker films and clumping and thus impedes bacterial attack. In addition, limited winter daylight reduces photochemical oxidation. Any oil in sediments of the Alaskan Gulf is expected to remain longer than in most Atlantic waters. Some weathering in Alaskan waters has been reported. [9] It is aided by turbulence.

Several recent spill studies provide some ideas on the persistence of oil. They are briefly summarized here.* [10]

- San Francisco. Tanker collision, Jan. 18, 1971. An estimated 20,000 barrels of Bunker C (residual oil) was released.† The oil entered two types of shallow habitats, rocky shores and mussel reefs, within several hours.

  An August 1971 survey showed reef mussels contaminated with oil, [11] implying that oil persisted in the mussel reef zone for at least 6 months. The investigators estimated that all "signs" of the oil would disappear from the rocky shores within 2 years of the spill. Because the survey employed only visual observation, 2 years is considered an underestimate.
- Chedabucto Bay, N.S., Canada. Feb. 4, 1970. A spill released approximately 70,000 barrels of Bunker C fuel oil, contaminating two intertidal habitats, sandy beach and rocky shore.

  A study conducted 26 months later showed that the mud bank had lost little of the originally observed oil. The salt marshes and estuarine lagoons retained 50 percent of the original oil content. [12] The data indicate that residence time of oil could be at least 3 years in the salt marsh and mud sediments.
- West Falmouth, Mass. Sept. 16, 1969. The barge FLORIDA ran aground, ruptured its hull off West Falmouth, and released an estimated 4,200 barrels of No. 2 fuel oil. Two years later, oil was reported in sediments and bottom organisms. [13] On the basis of gas-liquid chromatography, 28 percent of the oil in the sediments in April 1971 was considered aromatic. Oil found in the marshes 5 feet below the surface was predicted to persist in the sediments for at least 2 more years (4 years after the spill).
- Wreck Cove, Wash. Jan. 6, 1972. The unmanned troopship GENERAL M. C. MEIGS broke loose while under tow and went aground, releasing approximately 3,000 barrels of Navy special (residual) fuel oil. A storm broke the oil into

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*In these analyses oil which has been in the water for 1 or 2 days is described as "weathered."

†Distillate fuel oils are the lighter fuel oils produced in the refining process. They include Nos. 1 and 2 heating oil, diesel fuel, and No. 4 fuel oil. Residual fuel oils are the heavier products, including Nos. 5 and 6, heavy diesel oil, Navy special, and Bunker C (for heat, industrial uses, and power production).

globules 5 to 30 centimeters in diameter when observed on the beach. Oil was trapped for several months in the upper tidal pools of the rocky ledges. [14]

- Santa Barbara. Jan. 28, 1969. A blowout lasted several weeks and released an estimated 33,000 barrels of oil. Samples taken in the sediments on March 31, May 1, and June 13, 1970, showed no evidence of a reduced oil content over this period. [15] From 1972 to 1973 the sandy beaches were reported recovered from oil contamination, but weathered oil on the cobbles in the upper intertidal zone in February 1973 may be linked to the spill. These data indicate that residence time of oil could be at least 3 years in the salt marsh and mud sediments.
- Southwest England. March 18, 1967. TORREY CANYON. About 700,000 to 860,000 barrels of Kuwait (heavy) crude oil was spilled when the TORREY CANYON broke up at sea. Large amounts of emulsifiers were used in cleanup operations. In a few areas emulsifiers were not immediately used and oil was dispersed. Oil was visible for at least several months in both the rocky and sandy shores.
- Casco Bay, Maine. Nov. 25, 1963. Some 20,000 to 25,000 barrels of Iranian Agha-Jari (heavy) crude oil was spilled in Casco Bay. Color photographs taken in 1970 and 1971 were used to ascertain the presence of oil residue on rocks in Simmonds' lobster pound. [16] Chemical analyses of both sediments and soft shell clams on July 20, 1972, evidenced contamination 9 years after the spill.

Responses of Individual Organisms

Exposure to oil can affect an organism physiologically and behaviorally. Many of these effects are cellular. How oil affects individual organisms may be generalized as: direct lethal toxicity; sublethal disruption of physiological processes and behavior; effects of direct coating by oil; incorporation of hydrocarbons, causing tainting and/or accumulation of hydrocarbons (including carcinogens) in organisms directly or by food-web transfer; and changes in biological habitats.

Lethal toxicity (death) can occur when hydrocarbons interfere directly with cellular and subcellular processes, especially membrane activities. Sublethal effects may also involve cellular and physiological effects. Although they do not produce immediate death, sublethal responses ultimately can affect survival of individual organisms, their local population dynamics, and the dynamic equilibria of biotic communities.* Important in this category are disrupted behavior, higher susceptibility to disease, reduced photosynthesis, reduced fertility, and abnormal development.

Coating is generally associated with the high-boiling fractions of oil, weathered oil. It can be a problem for intertidal sessile species, plankton, and diving birds. Mobile organisms would seem to have the capacity to avoid prolonged exposure. Subtidal benthic species are somewhat protected from coating because oil does not occur as a film on subtidal substrates† except in the worst local spill situations. Coating smothers or mechanically interferes with movement and feeding or causes loss of feathers, loss of heat, salt balance problems, etc.

The incorporation of hydrocarbons, including carcinogens, is of particular concern because they accumulate in marine organisms and can be transferred to other organisms through the food web. Both tainting and accumulation of hydrocarbons can occur in marine organisms exposed to oil. Oil entering a salt marsh, for example, is found in virtually all marine organisms. [17] Once exposure is terminated, however, over time some species have recovered completely. [18]

Significant shifts in composition and distribution of species in a region result when a habitat is so changed as to become unsuitable or less suitable to a species which normally inhabits it. Intertidal and subtidal benthic species are therefore important subjects. How much and what kinds of oil prevent a species from utilizing a substrate, for example, are largely unknown, but in view of available data, the presence of low-to-medium boiling point aromatic hydrocarbons at concentrations as low as 10 to 100 parts per billion may chemically perturb many species. The effects of higher boiling, insoluble materials depend on how much an organism relies on his particular substrate and how much it is altered by oil. Species depending on a substrate only for passive support may be little affected by habitat changes caused by the oil. But those living in the substrate or otherwise actively depending on the substrate are surely more vulnerable.

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*A population is here defined as a group of individuals of the same species inhabiting the smae geographic region of the marine environment. A community is here defined as a group of populations occupying the same regions or biotic zone in a region.

†A substrate is the material or surface from which a plant or animal obtains support.

Still other effects are acclimation and selection, processes that may alter how individuals and populations tolerate concentrations of oil.

Table 6-8 lists the species selected for consideration. Although these are species that are frequently studied, there are relatively few data regarding their sensitivities to oil.

To assess toxic sensitivities, the data were aggregated, as shown in Table 6-9. Only two categories of marine organisms—adult and larval stages—were considered. Available data indicate that death may be expected in most adult marine organisms from exposure to 1 to 100 parts per million of total soluble aromatic hydrocarbon derivates (SAD) within a few hours' exposure. For larvae, lethal concentration may be as low as 0.1 parts per million of SAD. These lethal concentrations can result from unweathered oil slicks. SAD concentrations of 10 to 100 parts per billion may interfere with chemical sensing and communications, on which lobsters and anadromous fish depend.

Responses of Populations and Communities

The impacts of oil on local populations may be examined by considering parameters such as population size and age distribution. In looking at impacts, one must remember that accidental spills and chronic discharges are not the same. For accidental spills three general stages may be analyzed: prespill equilibrium, immediate postspill impact, and recovery to equilibrium conditions. In contrast, a continuous discharge results in oil contamination at low concentrations, which may not produce immediate, dramatic impacts but may instead show subtle, long-term effects.

Biological impacts are determined by the following factors:

- Type of oil spilled, in particular, the concentration of lower-boiling aromatic hydrocarbons
- Amount of oil
- Physiography of the spill area
- Weather conditions at the time
- Biota in the area
- Season of the year
- Previous exposure of the area to oil
- Exposure to the other pollutants
- Method of treatment of the spill. [19]

The potential oil spill impacts on two general populations, birds and fish, are briefly summarized here.

Birds

Oil spills are a considerable potential threat to bird populations. [20] Atlantic and Alaskan coastal habitats support thousands of species of birds and provide wintering, breeding, and feeding grounds. Some of these birds are rare or are near extinction. Birds are particularly vulnerable to oil for several reasons. When their inner feathers are coated with weathered or unweathered petroleum, insulation is lost, and a bird can literally freeze to death in any season. To suffer this fate, diving birds enter oil-slicked water, or shore birds move about in a habitat covered with washed-up oil. Birds diving directly into it may perish.

A total bird population is small compared to most aquatic populations. Small populations run a higher risk of extinction by whatever cause. Because many birds flock, an entire breeding population may be exposed to a local threat such as oil. Maturation usually requires 3 to 4 years, prolonging the recovery process. Further, that birds produce two to three young/breeding pairs each year severely limits a population recouping losses. Some species live 40 or more years and many live at least a decade. Reestablishment of a population's prespill age distribution could take decades.

Recovery time for bird populations is contingent on several factors about which there is little or no information—total population size, degree of aggregation of the species into discrete breeding stocks, and extent of kill. The latter depends on what part of the population visits the oiled area during the danger period, on feeding technique, and on migratory patterns and native habitats, which determine whether and when a population is in an area. Given the right circumstances, total elimination of a population is entirely possible.

Fish

There are five main ways that oil can damage local fish populations: (1) Eggs and larvae die in spawning and nursery areas from coating and from exposure to concentrations of hydrocarbons in excess of 0.1 parts per million (SAD). These concentrations occur in unweathered spills of crude offshore and crude or refined oil nearshore. (2) Adults die or fail to reach spawning grounds if the spill occurs in a critical, narrow, or shallow waterway. Anadromous fish homing to an estuary are particularly vulnerable to this situation.

TABLE 6-8

Effects of Oil on Selected Species[1]

Species	Common name	Lethal	Sublethal	Coating	Uptake and tainting	Habitat change
Birds						
Rissa tridactyla	Kittiwake			X		
Fishes						
Alosa spp.	Alewife	X				
Clupea harengus	Herring	X				
Fundulus heteroclitus	Mummichog	X				
Gadus morhua	Atlantic cod	X				
Micropogon undulatus	Croaker		X			
Morona saxatilis	Striped bass		X			
Pseudopleuronectes americanus	Winter flounder	X	X			
Crustaceans						
Acartia spp.	Zooplankter	X				
Ampelisca vadorum	Amphipod	X				X
Balanus balanoides	Acorn barnacle	X				
Calanus spp.	Zooplankter	X			X	
Crangon spp.	Shrimp	X				
Emerita spp.	Mole crab	X				
Homarus americanus	American lobster	X	X			
Paqurus longicarpus	Hermit crab	X			X	
Pandalus spp.	Shrimp	X				
Mollusks						
Asquipecten spp.	Scallop	X	X		X	
Crassostrea spp.	Virginia oyster	X	X		X	
Donax spp.	Coquina clam	X				
Mercenaria mercenaria	Northern quahog	X				
Modiolus spp.	Horse mussel		X		X	
Mya arenia	Soft-shell clam	X			X	X
Mytilus edulis	Edible mussel	X	X	X	X	
Littorina littorea and spp.	Periwinkle	X	X	X		
Nassarius obsoletus	Common mud snail		X			
Thais lapillus	Dog whelk	X	X			
Worms						
Arenicola marina	Lugworm	X	X			X
Nereis virens	Clam worm	X				
Streblospio benedicti	Polychaete	X				
Other animals						
Asterias vulgaris	Starfish				X	
Strongylocentrotus droebachiensis	Sea urchin	X			X	
Plants						
Juncus gerardi	Marsh rushes	X				
Spartina alterniflora	March grasses	X			X	
Spartina patens	Cord grass	X				
Laminaria spp.	Kelp	X				

[1] Does not list all species for which data have been reported. Rather, an X represents reported data for those species which were selected for special consideration. An X indicates that some data, regardless of number, have been reported.

Source: Massachusetts Institute of Technology Department of Civil Engineering, 1974, "Atlantic/Alaskan OCS Petroleum Study: Primary Biological Effects," prepared for the Council on Environmental Quality under contract No. EQC330.

TABLE 6-9

Estimated Acute Toxicity Sensitivity

[Parts per million]

Class	Estimated concentration of soluble aromatics causing toxicity
Plants	10-100
Finfish	5-50
Larvae (all species)	0.1-1
Pelagic crustaceans	1-10
Gastropods (snails, etc.)	10-100
Bivalves (oysters, clams, etc.)	5-50
Benthic crustaceans (lobsters, crabs, etc.)	1-10
Other benthic invertebrates	1-10

Source: The Massachusetts Institute of Technology Department of Civil Engineering, 1973, "A Preliminary Assessment of the Environmental Vulnerability of Machias Bay, Maine to Oil Supertankers," prepared for the Council on Environmental Quality (N.T.I.S. Accession No. COM-73-10564).

(3) A local breeding population is lost due to contaminated spawning grounds or nursery area. (4) Fecundity and spawning behavior are changed. (5) Local food species of adults, juveniles, fry, or larvae are affected.

Of the above, only the effects on eggs and larvae in spawning and nursery areas have been studied in some detail. How the eggs or larvae of individuals born in a particular year are impacted depends on the time of year of the spill as well as season and duration of spawning, the fraction of the local population or spawn encountering the spill, and the type of eggs and larvae.

The species selected for consideration in each region are summarized below:

- Northern New England, Maine to Cape Cod. Seven finfish and shrimp were considered–the alewife, Atlantic salmon, Atlantic herring, winter flounder, cod, sand lance, and mummichog. Those potentially vulnerable to oil spills are the winter flounder, sand lance, mummichog, and possibly the alewife and salmon. Northern shrimp, primarily in the inner Gulf of Maine, appear unthreatened except for inshore spills; even then, the population is large and widely dispersed.
- Southern New England, Cape Cod to Sandy Hook. Eighteen species were considered–including the mackerel, summer flounder, bluefish, striped bass, and bluefin tuna, in addition to those listed for northern New England. Potentially most vulnerable to oil spills are the summer and winter flounder, tautog, and sand lance. The anadromous smelt, alewife, and striped bass are also vulnerable.
- Middle and South Atlantic, Sandy Hook to Cape Canaveral. Ten species of fish were considered the hogchoker, croaker, spot, gray trout, menhaden, striped bass, spiny dogfish, scup, summer flounder, and southern kingfish. The hogchoker and summer flounder appear most vulnerable to oil.
- Gulf of Alaska. Several salmon and groundfish species are important in the Gulf (see Table 6–7). Very sensitive to oil spills are their spawning and nursery areas and streams.

Recovery

A local species population has recovered from an oil spill when it recolonizes and density and age distribution return to prespill levels. Recovery is not considered complete until prespill size and age distributions have been restored, with allowance for natural fluctuations. This strict criterion does not reflect complete recovery that might occur in more complex situations. For example, the ecological successions involved in local population or community recovery might result in a new equilibrium that differs qualitatively or quantitatively from prespill conditions. The difference does not necessarily indicate degradation or lack of recovery.

In the M.I.T. predictive models, four major stages of population recovery were identified: (1) assuming survival of part of the original population, recovery begins with survivors, (2) colonizers enter the recovery area, (3) colonizing individuals settle or otherwise reestablish, and (4) recovery is completed. In annual species, recovery occurs when prespill population density is reached; recovery in perennial species is equated with return to a prespill stable age distribution within the local population.

A complete analysis of recovery requires understanding of interrelations among species and of the internal dynamics of each population, but data are largely unavailable. By using what data are available, M.I.T. postulated four classes of recoverers based on mode of colonization and expansion in unsettled, hospitable habitats.

"Wide-dispersal ubiquitous species," the most common marine biotic category, are the populations whose prespill habitat is accessible to reinvading members of the species in a single reproductive season and who number enough "immigrants" to replace local prespill populations. Recovery time is of the order of the lifespans of individual organisms.

"Wide-dispersal non-ubiquitous species" are the populations whose prespill habitat is accessible to reinvading members of the species in a single reproductive season but who may not have enough settlers to repopulate the local area quickly. This category may be vulnerable to occasional biotic catastrophes (occasions of high adult mortality). Birds are in this group; their recovery time, though largely unknown, is highly variable.

"Non-wide dispersal species" are populations whose prespill habitat is not accessible to reinvading members of the species. Some snails are an example. Recovery times are likely to be longer than the lifespans of the species. This group is very sensitive to catastrophic spills because it takes longer than other categories to repopulate a decimated zone.

"Highly mobile species," like finfish and birds, appear significantly vulnerable only during highly localized breeding or other types of aggregations at various times of the year. The significance of such a threat is extremely difficult to project. The M.I.T. analysis indicates that planktonic organisms* and diving birds are potentially more vulnerable to exposure to oil in the open sea than nektonic organisms, which can swim about. However, a single oil slick should not threaten an entire planktonic population. Species with small or local breeding populations such as anadromous fish native to a particular river—the alewife, striped bass, and salmon—may be especially vulnerable.

One question that the study sought to answer was whether biological differences among habitats provide a basis for distinguishing habitat differences in the time required for recovery from oil spills. It appears that such a distinction based on recovery times cannot be made, although this is not to say that habitats are the same in their susceptibility to or ability to recover from effects of oil spills. Available data simply do not provide sufficient bases for identifying such generic biological differences. This conclusion is significant because it indicates that a decision to drill in one region as opposed to another cannot now be based on recovery analyses of various habitats within a region.

On the other hand, special characteristics of an area—the presence of endangered species, nursery grounds, and spawning grounds—allow a measure of biological differentiation among regions, and these kinds of areas should be protected. For example, stipulations have been placed on Gulf of Mexico OCS leases to prevent damage to unique coral reef communities and to protect highly sensitive coastal resources.

Continuous Spills

Under present practices, low-boiling fractions of oil are released in the effluent of oil-water separators mounted on platforms. As much as 50 parts per million of oil, primarily soluble components, may be continuously discharged from each platform oil-water separator unit. A local plume is formed and the subsurface contaminated. Based on M.I.T.'s conservative assumptions in the Georges Bank study, a single central separation platform (processing 200,000 barrels per day) releases separator effluent at a constant rate of 3 cubic feet per second. At a maximum oil concentration of 50 parts per million in the effluent, such a platform may discharge somewhat less than 1,000 barrels of separator oil per year. By making other conservative assumptions about the effective mixing depth, dispersion coefficient, and local currents, the discharge plume for such a platform could be expected to produce a maximum area (at the surface) of 2 square miles at the 100 parts per billion oil-concentration contour and would extend to an average depth of 3 feet. Analyses which assume deeper mixing zones yield exponentially decreasing plume areas at the surface.

The biological significance of this continuous spilling is not well understood. On the one hand, the amount released at one platform in a year's constant operation is small relative to accidental spills. By way of comparison, the West Falmouth spill involved nearly five times more oil. In addition, the separator effluent is a controllable discharge. Moreover, its continuity might promote the establishment of local microbial degraders near a platform.

On the other hand, the water-soluble components of oil contained in separator discharge include the more toxic components of crude oil. Biological effects of such low-level constant oil discharge may differ considerably from the effects of any large and sudden accidental spill. Factors such as how many separators and platforms and how near shore they should be are important.

Mobile aquatic organisms such as fish, squid, and marine mammals—assuming appropriate sensory and behavioral responses—appear capable of avoiding contaminated areas near a platform. Whether they in fact do is a question, but the lack of significant fish kills observed from marine oil spills suggests that they may. [21] Of course, that kills have not been observed could conceivably result from the large numbers of fish simply not being in the surface waters affected rather than from any avoidance responses.

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*Those which passively inhabit the water column, being unable to swim against a current (e.g., algae, microscopic animals).

Plankton and some of their predators (e.g., arrow worms and shrimp) are carried by currents through the plumes. The most sensitive larvae and zooplankton, phytoplankton, and predators will probably die from passage through the plume, at least the more concentrated parts of it. M.I.T. argues that these losses are unlikely to affect populations severely because only a small fraction of a widely dispersed planktonic population will encounter a local continuous plume. This argument is based on a comparison of the limited extent of these continuous plumes in relation to the entire area. However, with this simple argument one is not able to gain any perspective on how such losses relate to other stresses on local plankton populations. That is, are there important cumulative or synergistic effects? And regarding discharged separator oil in the food web, tainting and accumulation of oil residues in some organisms can affect other biota.

Any highly aggregated local population would be threatened by a platform and its associated separator slick in the vicinity of a critical area. Placement of platforms in regions of upwelling, which usually support high densities of pelagic organisms, could be

How and how much oil accumulates in the sediments beneath an ocean platform depend on the sediments and on effluents, currents, and other variables. The oil moves downward in several ways. Molecular diffusion transports significant quantities downward about 5 meters. [22] Strong waves may drive it as deep as 80 meters, so that oil could reach the bottom at Florida sites. Probably the most significant transport mode involves sedimentation, when oil is absorbed by suspended particles that settle. Heavier oil fractions may sink with their own weight after losing their lighter fractions and accumulating sediment.

The formation water produced during operations may be fresh, or it may contain the mineral salts of iron, calcium, magnesium, sodium, and chlorine. Discharge of this water and its oil not only increases the mineral content of the water but can lower dissolved oxygen levels. Current OCS orders require an average oil content no higher than 50 parts per million at discharge. This oil may contain a relatively high percentage of water-soluble aromatics which are potentially toxic.

Discussion of risks regarding separator effluent in northern waters is speculative, but conservative practice would require treating the effluent to remove most soluble hydrocarbons or transporting wastes to shore. Deepwater and coarse sediments appear to be biologically preferable features of a drilling site.

Biological Effects of Pipeline Construction

Crude petroleum piped from outer continental shelf production areas to terminals onshore could traverse ecologically rich coastal areas. The marshes and wetlands are the home of hundreds of birds, waterfowl, fur-bearing animals, reptiles, fish, and invertebrates. The coastal areas are also highly prized for their sport, recreational, and aesthetic values. Other activities that can be environmentally damaging are the construction of support facilities onshore, the storage tanks, crew bases, refineries, and petrochemical plants, and the creation of barge and navigation channels. In fact, the dredge, fill, and channelization activities in the Gulf of Mexico may have caused more damage than pollution from oil. Although a number of Atlantic coastal areas are similar to the Gulf of Mexico coast, the rocky shores of New England are considerably different.

The impact of construction on plant communities is generally focused on vegetation lost by dredging a canal and disposing of the spoil. Additional vegetation may be lost through erosion of canal banks, compaction of vegetation and soils, and regular or periodic flooding by more saline (or fresh) waters than were previously experienced. If the water table is lowered because of land drainage, loss of vegetation may result from hydrogen sulfide toxicity or may completely change the vegetation pattern.

Construction impacts animal populations directly by taking away their homes and food, by dividing populations, and by generally disturbing them. Often construction destroys submerged bottoms and coastal wetlands along with the organisms that live there. Birds respond to habitat perturbation in different ways. Some migratory birds are not measurably affected, others merely shift their nesting and feeding areas, and still others abandon the habitat completely.

Salinity is a parameter of great importance to aquatic life in the coastal zone. Changing drainage patterns may cause salinity to fluctuate or to change totally, which in turn will affect resident organisms. Large quantities of silt may be released; it can smother bottom-dwelling plants and animals, clog fish gills, and change the organism's behavior. Particularly susceptible to silting are oysters and other shellfish. High turbidity reduces vision and can mask odors, both important to survival of many fish. Turbidity also decreases light penetration into the water, thereby reducing photosynthesis and productivity and lowering dissolved oxygen concentration. Additionally, depositing spoil changes the distribution of nutrients.

There are also aesthetic effects from pipeline construction. Scars are created and spoil is deposited along canals. Revegetation may be difficult. Depressions in the land may result in long-term changes in currents and water circulation, which affect the mixing and flushing of estuarine waters and eventually change water temperature, salinity, dissolved oxygen, sediment accumulation, and therefore productivity. Dredged channels modify overland and river flow, runoff drains more rapidly, the duration of freshwater inflow is reduced, and salt water is given a way to intrude.

CONCLUSIONS AND RECOMMENDATIONS

The direct impact of offshore oil and gas development may result from accidental oil spills or the chronic discharges of normal operations, from disposal of drilling muds and cuttings into the ocean, and from disturbance of the ocean bottom and wetlands by platform and pipeline construction. Although massive oil spills caused by blowouts, fires, and tanker collisions receive the most publicity, it is the routine production of oil and gas that presents considerable environmental risk.

Daily operational discharges of oil, drilling muds, cuttings, and other material may result in sublethal or long-term ecological damage to an area. In several recent studies, significant concentrations of heavy metals were found near platforms. They enter the food web and could pose problems for human health. Because of concern about the impacts of long-term, low-level discharges of oil into the ocean, it is important that daily operations be carefully monitored and that stringent standards for discharge of oil, muds, and cuttings be strictly enforced.

The absence of data on offshore fisheries makes it difficult to determine the relative vulnerability of various regions. Oil spills offshore will pass over and through a number of ecologically diverse areas. Sensitive areas should be avoided by platforms, pipelines, and tankers. Potential impacts on commercial fisheries should be assessed before development begins.

Nearshore spills are particularly damaging to estuarine life. The tidal marshes, coastal wetlands, river swamps, and sheltered bays support a variety of organisms at all stages of development. Oil spilled nearshore has a stronger likelihood of reaching shore more quickly than oil spilled at areas more distant from shore. If it reaches shore within 1 or 2 days, extensive mortality is to be expected initially in all exposed habitats; they may require years to recover. All the harbors and bays examined could experience such an impact. This finding indicates that benefits can be derived from siting refineries inland and using offshore transfer points.

The probability that oil spilled will reach the shore and the time that it will take depend on how far from shore the oil is spilled and on the wind and current patterns. From the standpoint of oil coming ashore, drilling sites farther from the coast offer lower environmental risk.

Oil spills in the eastern Georges Bank (east of 68°W, EDS 1 and 2) have lower probabilities of coming ashore and would take longer to reach shore than those in the western Georges Bank. If oil should reach shore from Georges Bank, it would have the shortest physical residence time on the rocky shores. Assuming that prime fishing areas are avoided and that pipelines and tanker routes remain away from Cape Cod, the eastern Georges Bank appears to be one of the two areas least vulnerable to major environmental damage.

The other area with low vulnerability is the southern part of the Baltimore Canyon Trough. The probability of an oil spill coming ashore from hypothetical drilling site EDS 9 is near zero in all seasons. Assuming that platforms and pipeline corridors are sited in order to minimize impacts on critical areas, this site in the Baltimore Canyon Trough south of 37°N would have low environmental vulnerability.

The western Georges Bank (west of 68°W, EDS 3 and 4) and central Baltimore Canyon (between 37° and 39.5°N, EDS 6, 7, and 8) follow in order of potential vulnerability to physical and biological damage. The northern Baltimore Canyon and Southeast Georgia Embayment appear even more vulnerable to both oil spills and continuous discharges. Oil spilled or discharged in these areas has generally escalating probabilities of coming ashore, shorter times for reaching shore, and a greater chance of entering estuarine and wetland areas.

Although the fate of oil spilled in the Gulf of Alaska may be hypothesized, the populations potentially exposed are not well characterized. The few data available for the Atlantic are much more extensive than for Alaska. Available data indicate that both the coastline and offshore area in the Gulf of Alaska are most important nesting, spawning, and feeding grounds and that these pristine environments could be damaged by oil-related accidents and chronic discharges.

Birds are particularly important in the Gulf of Alaska region; over 200 species are found along the coast. Whole populations of some species, such as the dusky Canada goose are known to breed here. The Gulf is also rich in marine mammal life. Some species are endangered and could be seriously jeopardized by large oil spills.

The analysis of spill movement from drilling sites ADS 1 through ADS 6 shows high probabilities of oil coming ashore from Cape St. Elias to the Kenai Peninsula; the possibility of widespread coating of shorebirds, seabirds, and waterfowl in this region is serious. ADS 7 through ADS 9 appear preferable because of lower probabilities of oil coming ashore and less danger to assorted bird populations.

Of the areas studied, the Council concludes that because of its tremendous ecological value as a habitat for many rare, endangered, and important species, the longer physical residence time of oil, and its hostile environment, the Gulf of Alaska appears most vulnerable to major environmental damage from OCS oil and gas development.

To determine where development should and should not occur and to measure the effects of development, baseline studies should be initiated as soon as possible. The studies must be carefully designed to ensure that the most useful data are collected and analyzed. The Bureau of Land Management has increased its budget to conduct this kind of environmental study. Further, BLM has established a joint Federal-state OCS management research advisory committee to assist in the design and implementation of frontier OCS area studies. The Council supports this effort and the parallel efforts by the National Oceanic and Atmospheric Administration, the Environmental Protection Agency, and the Bureau of Sport Fisheries and Wildlife. Monitoring information can be quickly integrated into ongoing operations and plans and guidelines for new lease areas. These baseline studies will be useful in determining locations for marine sanctuaries.

The Council believes that the following research is necessary:

- Basic studies of population life histories for many species, including identification of survivorship, fecundity, larval life style, migrations, behavior, etc.
- Community response at the species level following pollution incidents or in controlled experiments
- Petroleum degradation processes and weathering rates as a function of temperature, light, nutrient concentration, etc.
- Physical-chemical relationship of oil hydrocarbons and sediment materials, including transport
- The effect of sediments on degradation of low-boiling aromatic fractions
- Identification of specific toxic hydrocarbons
- Adaptations of organisms to oil, including genetic changes
- Sources of oil in the ocean environment
- Amounts and impacts of heavy metals discharged during operations
- Impacts of oil during sensitive stages of species development
- Release and fate of carcinogenic components of oil
- Effects of oil on commercial fisheries
- Effects of oil on the food web
- Correlation of drift bottle data and movement of oil
- Currents near Chesapeake Bay, Cape Hatteras, S.C., and all the Gulf of Alaska
- Physical and biological data for the Gulf of Alaska.

These research activities, although not essential before development, should be actively pursued.

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19. Adapted from D. Straughn, "Factors Causing Environmental Changes after an Oil Spill," *Journal of Petroleum Technology* 24:250, March 1972.

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22. *Primary, Physical Impacts of Offshore Petroleum Developments,* supra note 2, Section IV, at 6.

Chapter 7. Onshore Effects Of OCS Development

As the development of offshore oil and gas proceeds from the initial exploratory phase through drilling, production, and transportation, substantial onshore activity will be generated, from which both positive and negative impacts can be expected. The degree to which on balance these effects are positive is related to the ability of public officials to plan for and direct the onshore development that is integral to OCS development and to plan for the growth that onshore facilities generate throughout the region. Refineries, petrochemical complexes, construction industries, and related service operations increase employment opportunities, economic output, and income, but the growth that they cause will strain existing public services, bring additional land under commercial, residential, and industrial development, and add to air and water pollution.

These onshore impacts are an important component of any OCS development decision. This chapter examines their magnitude and relative importance and suggests key development issues facing local and state authorities. It is based largely on a contract study undertaken for the Council on Environmental Quality by Resource Planning Associates, Inc. (RPA). [1] The chapter also draws upon recent oil and gas production experience in the North Sea, operations in the Gulf of Mexico, and testimony presented at the CEQ public hearings.

Although strictly illustrative, this kind of analysis provides a framework for understanding the range of economic, social, and environmental impacts of onshore development possible from a decision to produce OCS petroleum and provides a methodology for planning by state and local officials faced with difficult and complex land use and growth decisions in the years ahead. OCS operations will result in massive development in areas where there is little or no experience in land use planning or regulatory activities. Unless this capability is quickly developed in such areas, the result could be permanent degradation of the environment and unnecessary disruption of traditional values and lifestyles for those living there now. It is the fear of the latter which lies at the center of much local opposition to the siting of energy facilities being voiced throughout the country today.

The RPA study used available data sources when possible because the short time frame limited extensive original data collection. Detailed reviews were made of published materials and area master plans. The study also built upon some of the economic methodology used in a recent study by Arthur D. Little, Inc., for the Council on Environmental Quality on the potential onshore effects of deepwater terminals. [2] Numerous industry, government, and public sources were consulted.

ASSUMPTIONS

This study is based on a set of complex geographical and industrial development assumptions for each region examined. The assumptions concern the sites selected and estimates of industrial development and production. It is important to note that the sites were selected for analytical purposes only.

Sites for Analysis

Eight sample onshore oil and gas receiving centers were chosen for detailed study. These sites—four on the east coast, two on the west coast, and two in Alaska–present a variety of conditions and potential impacts. Their selection from among 21 sites identified on the east coast and 13 in Alaska and on the west coast was based on the following criteria:

- At least one site in each major demand area (North Atlantic, Mid-Atlantic, etc.)
- Proximity to hypothetical offshore drilling sites (identified by the U.S. Geological Survey) and distribution markets onshore
- A mix of developed and undeveloped localities and regions to provide a range of base conditions and impacts
- A mix of base economic conditions
- Proximity to potential deepwater loading and unloading areas
- Availability of data.

The sites are all listed in Table 7-1, and the locations of the ones chosen for analysis are shown in Figures 7-1 and 7-2. The counties chosen are those where oil and gas could be brought ashore; where refinery, gas processing, petrochemical, and construction activities would develop, and for which socioeconomic and environmental data are obtainable.

Base Case Development Assumptions

What happens onshore as a result of offshore development is best understood in terms of current socioeconomic and environmental conditions and normal growth with no OCS production. Projections to the year 2000, however, are at best uncertain. To compensate, the Council examined several development assumptions.

For the east coast–Petroleum Administration for Defense District 1 (PAD 1)–the difficulty in predicting future development absent OCS production led to use of two base cases for analysis. Both assume continued oil imports and exclude OCS production. Base Case 1 doubles onsite refinery capacity to 3 million barrels per day by the year 2000. It assumes that no new "grassroots" refineries will be sited, and it depends more on Gulf coast and imported refined products. While this case does not reflect the lowest growth possible, it takes into account the demand projections in Chapter 3 and the expected need for more refinery capacity.

Base Case 2 assumes construction of deepwater ports in each of the three east coast demand areas (New England, Mid-Atlantic, and South Atlantic) that will serve the nearly fivefold increase in refining capacity from 1975 to 2000–over 7 million barrels per day.[*] This case assumes that each region approaches a 50 percent self-sufficient refinery capacity by 2000–a goal that may be impossible for New England and the South Atlantic without extensive new refinery siting and growth.

TABLE 7-1

Hypothetical Onshore Development Areas Considered for Analysis

East Coast Hypothetical Receipt Points
Eastport, Me.
Bangor, Me.
Portland, Me.
Boston, Mass.
Bristol County, Mass.*
Narragansett Bay, R.I.
Long Island, N.Y.
Raritan Bay, N.J.
Cumberland/Cape May Counties, N.J.*
Baltimore, Md.
Chincoteague Bay, Md.
Hampton Roads, Va.
Albemarle Sound, N.C.
Georgetown, S.C.
Charleston, S.C.*
Beaufort, S.C.
Savannah, Ga.
St. Catherine's and Sapelo Sound, Ga.
Jacksonville, Fla.*
Brevard County, Fla.
Stuart, Fla.
West Coast Hypothetical Refining Sites
Puget Sound, Wash.*
Columbia River Inlet, Ore.
San Francisco Bay area, Calif.*
Monterey Bay, Calif.
Los Angeles, Long Beach, Calif.
Alaska Hypothetical Receiving and Transshipment Sites
Yakutat Bay
Cordova*
Valdez*
Anchorage
Seward
Kodiak Island
Kenai
Katalla

*Sites chosen for analysis.

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[*] Two types of refineries could support both Base Case 2 and the OCS development cases. The first and technically simpler type is a fuel oil refinery producing low-sulphur fuels and naphtha for petrochemical feedstocks, powerplants, and SNG plants. The second and more complex is the integrated refinery, producing gasoline, distillates, and other light fuels.

The fuel oil refinery is expected to locate near a source of water transportation because almost one-half of its products

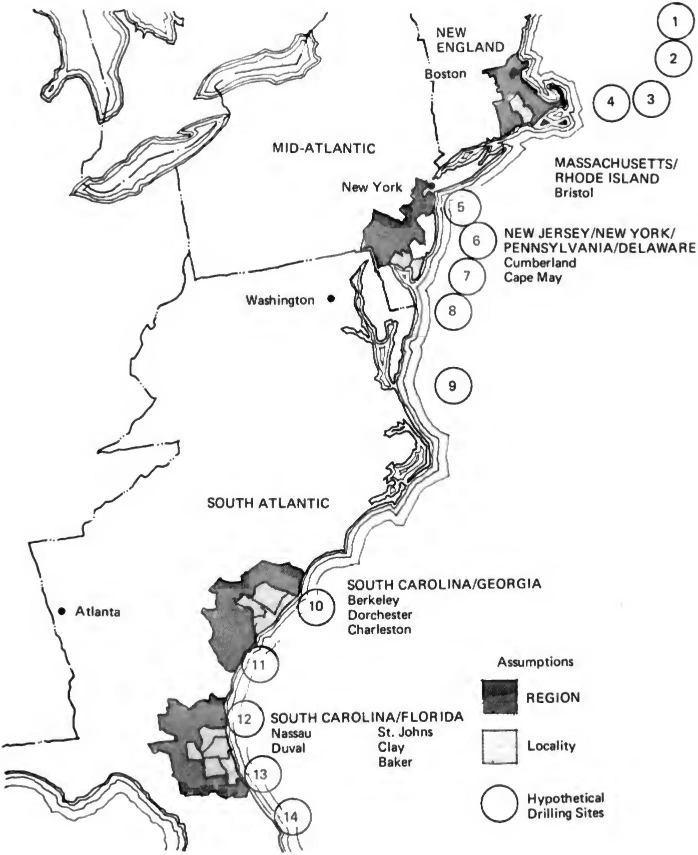

Figure 7-1. Atlantic Hypothetical Drilling Sites and Hypothetical Onshore Development Areas

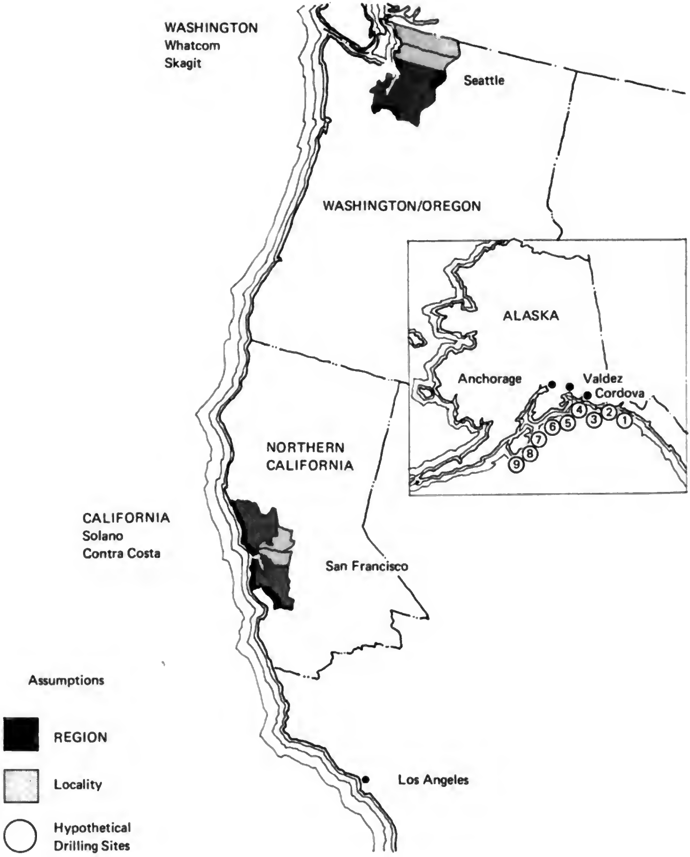

Figure 7-2. West Coast Hypothetical Drilling Sites and Hypothetical Onshore Development

No gas processing is assumed on the east coast for either base case. Some petrochemical* development is assumed in Base Case 1 in the Mid–Atlantic; in Base Case 2 significant petrochemical development is assumed for the Mid-Atlantic and the South Atlantic. Feedstock availability is one of the main factors affecting both location of petrochemical complexes and growth of the industry. Perhaps most important to petrochemical development is the expected shift in feedstocks from natural gas liquids (NGL) to heavy liquids (e.g., naphtha and gas oil), brought about by an expected limited supply of NGL and its use as a fuel. Unless significant new natural gas discoveries are made, NGL use for petrochemicals in the year 2000 could remain at present levels or even decrease. In any event, future NGL will be limited, and naphtha and gas oil will replace it in new petrochemical development. This study assumes new domestic refinery output used for new pettrochemical feedstock at 9 to 10 percent in 1985 and 12 to 13 percent in 2000. Any additional feedstock requirements are assumed met by imports or new NGL supplies. In Base Case 2, New England's petrochemical growth will be lower than other areas' because of the area's lower refining capacity and the need for refinery output as fuel.

Because the west coast (PAD V) is now virtually self-sufficient and has refineries in several locations, refinery growth is more predictable. Therefore only one base case was analyzed. Under this case, refining capacity is expected to increase from today's 2.2 million barrels to 3 million per day by 2000. No refineries are assumed for Alaska because of the small market for refined products there and the economic advantage of shipping crude oil to refineries near the large west coast markets. In each PAD V demand area, added refinery capacity was estimated only to the point of self-sufficiency for the area.

This study assumes that all Gulf of Alaska crude oil going to the Puget Sound and San Francisco regions will require additional refining capacity beyond that constructed for North Slope or imported crude. To the extent that Gulf of Alaska replaces North Slope or imported crude, the impacts outlined here are overstated.

Base case gas processing is assumed only in Alaska, reaching 10 billion cubic feet per day by the year 2000. Petrochemical development, not assumed in Alaska, would generally follow new refinery development in the Puget Sound and San Francisco regions.

OCS Development Assumptions

Industrial development is difficult to predict, but it is even more difficult to estimate oil and gas production levels. In fact, there is no assurance that OCS oil and gas exist in economically producible quantities. Nonetheless, the Council analyzed high and low levels of production for oil and gas in each area for 1985 and 2000 (see Table 7-2). The estimates represent extreme values for production, with a base case of no commercial production.† The estimates were derived by

TABLE 7-2

Estimated Atlantic and Gulf of Alaska OCS Production

	1985	2000
Atlantic[1]		
Oil (million barrels per day)		
Low	0.25	0.50
High	0.75	1.50
Gas (billion cubic feet per day)		
Low	0.30	1.80
High	0.90	3.60
Gulf of Alaska		
Oil (million barrels per day)		
Low	0.25	1.00
High	0.75	2.00
Gas (billion cubic feet per day)		
Low	0.30	2.40
High	0.90	7.20

[1] For each of the three potential OCS producing areas.

Source: Resource Planning Associates, Inc., and David M. Dornbusch & Co., 1974, "Potential Onshore Effects of Oil and Gas Production on the Atlantic and Gulf of Alaska Outer Continental Shelf," prepared for the Council on Environmental Quality under contract No. EQ4AC002.

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cannot be transported by pipeline. In contrast, over 80 percent of the integrated refinery products and their facilities could as well locate inland near existing pipeline systems. However, it seems reasonable that economic considerations would often dictate attaching fuel oil refineries to the more complex integrated refineries.

*Petrochemicals are manufactured from refined petroleum products (e.g., naphtha) and natural gas liquids. Directly produced from these raw feedstocks, they are further processed into a wide range of chemical derivatives (e.g., dyes, resins, and fibers), from which many end products are made, including paints, textiles, rubbers, and plastic products.

†The Council recognizes that production ranges may be controversial. Several oil industry representatives expressed concern about the Government's capacity to establish lease sales, availability of drilling rigs and other equipment, need for large acreage, environmental pressure, capital availability, etc. Yet others say that one giant field could dwarf CEQ projections, especially for 1985. CEQ believes, however, that the estimates are a reasonable basis for decisionmaking.

reviewing predictions of recoverable resources and by assuming lease sales beginning in 1976, exploratory drilling in 1977, and first production platforms in 1980.* A typical development scenario for a high-recovery area in the Atlantic could result in 1,440 producing wells by 1991 (see Table 7-3). Production estimates for the Atlantic are for each major recovery area separately—Georges Bank, Baltimore Canyon, and the Southeast Georgia Embayment. Although it is questionable whether all three would reach the high-production case at the same time, any one of them could reach that level; thus the analysis examines the high impact case in each region separately.

OCS production impacts were assumed additive to base case development on both coasts. As such, OCS production would supplement crude oil and gas imports and would require new refinery and gas processing capacity. In practice, OCS production may replace some imported crude. Despite this possibility, the number of base case/OCS impact case combinations is sufficient to include the absolute level of refinery production possible under a variety of situations. All combinations are examined in detail in RPA's report.

On the east coast, OCS oil and gas are assumed to be refined and processed in the demand area adjacent to the production area. Petrochemical development would generally follow refinery growth, as in the base cases.

TABLE 7-3

Atlantic OCS High Development Timetable[1]

Exploration		Platform development				Oil produced 10^3 bbl/d	Gas produced 10^6 ft^3 bbl/d
Year	Rigs/ wells	Install	In place	Oil wells drilled	Total oil wells-producing		
1976	3/12						
1977	3/12						
1978	3/12						
1979	6/24						
1980	8/32	2	2	16	16	17	
1981	10/40	4	6	48	64	67	
1982	10/40	8	14	112	176	183	
1983	10/40	8	22	160	336	350	
1984	10/40	8	30	192	528	550	
1985	10/40	8	38	192	720	750	900
1986	10/40	6	44	176	896		
1987	10/40	6	50	160	1,056		
1988	10/40	6	56	144	1,200		
1989	10/40	4	60	128	1,328		
1990	10/40	4	64	80	1,408		
1991	10/40	4	68	32	1,440	1,500	
1992							
1993							
1994							
1995							
1996							
1997							
1998							
1999							
2000			68		1,440	1,500	3,600

[1] For each region.

Source: Resource Planning Associates, Inc., and David M. Dornbusch & Co., 1974, "Potential Onshore Effects of Oil and Gas Production on the Atlantic and Gulf of Alaska Outer Continental Shelf," prepared for the Council on Environmental Quality under contract No. EQ4AC002.

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*The leasing and development schedule was chosen for analytical purposes only.

West coast gas would be processed in Alaska at the onshore receiving site for shipment via LNG tanker. Oil would be transshipped to the west coast demand areas. Here too, petrochemical development would follow new refinery development.

Construction activity peaks during periods of high industry growth and drops to low levels during conditions of slow growth or stable economic output. RPA chose 1985 as the peak construction year. The 1985 construction depends, of course, on the post-1985 development expected in a region (both primary construction–the heavy construction directly associated with refineries, petrochemical complexes, and gas processing plants–and induced construction–that associated with the other industrial, commercial, and residential activities resulting from the growth of primary industries and OCS development generally. Induced construction includes transportation facilities, especially expanded road networks; public services, including schools, hospitals, and recreational facilities; and new homes.)

The 1985 construction level assumes that all refineries and gas processing plants built between 1985 and 2000 will follow the offshore oil and gas production scenarios, reaching full capacity by about 1990 on the east coast and about 1995 in the Gulf of Alaska. Petrochemical production may lag behind refineries somewhat, and platform fabrication is not expected to have a major impact on the east and west coasts.

The industrial development assumptions used in this analysis required extensive study and were reviewed by numerous experts. Indeed, they are too complex to detail here. Rather, the reader is referred to the RPA report. [3]

IMPACT FINDINGS

Development of support and service industries onshore is viewed as good by some and bad by others. The difference was quite clear at the CEQ public hearings in September and October 1973. Many, including representatives of the petroleum industry, regional utilities, local businesses, chambers of commerce, and government officials, testified that economic gains to particular regions and the growth of new industries not only are beneficial but are urgently needed. They cited high unemployment rates, the need for petroleum, and a desire for economic diversification as reasons for developing the outer continental shelf.

Others said that their communities could not accommodate the volume and pace of development likely–not just the construction of refineries and other processing facilities but the residential and commercial development needed to support the influx of population and economic activities. Their concerns were not limited to wetlands, beaches, and other natural areas; they also feared the loss of traditional values, established lifestyles, and the character of their communities. Often cited were the lack of planning and land use regualtory mechanisms to cope with the development pressures. And some saw irreconcilable conflicts between industrial development and recreation, tourism, and commercial fishing.

Clearly, offshore development would make economic, social, and environmental changes onshore.

Economic Impacts

Economic impacts are measured here in terms of employment and value of output in the construction, refining, gas, and petrochemical industries as well as agriculture, utilities, other manufacturing, and services. The tax base in an area can show large gains. Employment effects will be significant. Low overall unemployment rates or even reduced unemployment among a local population will not necessarily result due to workforce mobility. This has been illustrated in Alaska, where the proposed Trans-Alaska Pipeline has attracted more workers than are needed. A similar phenomenon is likely for onshore petroleum activities resulting from OCS development.

These impacts will not always be positive. New employment in primary industries may be offset by losses of jobs in the resort, tourism, and fishing businesses. Although total fishing catch may rise, average per capita income of fishermen may decrease, as has happened in Kenai, Alaska. Recreation income will grow if hotel and restaurant earnings are considered, but resort business may suffer. However, it should be recognized that resort businesses can be severely hurt by energy shortages, as happened in some areas this winter. Many of the new jobs are skilled and may require workers from outside an area, as in Scotland in support of operations in the North Sea.

Social Infrastructure Impacts

Major components of the social infrastructure are physical systems, service systems, and business and government institutions. Physical systems are the structural resources essential to a community–the water supply, the energy supply, the residential and commercial buildings, and the various sectors of the transportation system. Service systems support and maintain a given community. They are education, law enforcement, health care, sewage handling, solid waste management, and government planning and organization. Business and government institutions provide the basic structures and services essential to a community—the commercial, industrial, and government units.

Increasing the population is how onshore development and OCS-induced growth would primarily change the infrastructure of an area. Rapid growth of population places the greatest strain on the infrastructure. New residents mean more water, sewers, electrical energy, schools, hospitals, and so on. Industrial growth also places demands on the infrastructure.

Regional infrastructure impacts are, in essence, a function of a larger population induced by economic expansion and the associated demands for basic public services.* Where growth has already occurred, new growth spurred by OCS development may make only marginal demands upon the existing infrastructure. Other, particularly smaller, communities may be faced with the need to create entire new infrastructures in a very short time. They may not be prepared or willing to handle the new demands, thus creating a situation whereby associated impacts are simply unacceptable. An illustration of potential population dynamics is shown in relation to North Sea development where mid-1970 populations are expected to increase by about 10 percent in Aberdeen, Scotland (20,000 new residents), 20 percent in Inner Moray Firth (20,000), and 50 percent in the Shetland Islands (8,000). [4]

Environmental Impacts

Environmental impacts are the land development, disruption from construction and temporary facilities, increased air and water pollution, changes in plant and animal habitats, and noise pollution from construction and operations. Although each sample region has enough "undeveloped" land to absorb these changes, the land is not necessarily "available." Indeed, it may be unsuitable for industrial development, and large tracts may well be unavailable because of their value as wetlands, beaches and dunes, wildlife and rare species habitats, historic areas, etc. or because of locational constraints—the availability of water, the slope of the land, and the distance from major population centers. Perhaps more important, large land areas could be consumed and wasted by poorly planned residential, commercial, and supportive industrial uses. Finally, many existing communities may require large buffer zones to protect them from what they consider land use that conflicts with their traditional values. When the total of these land areas is examined, the acreage for OCS-related growth diminishes significantly in every case.

Air pollution emissions from induced onshore development estimated for particulates, sulfur oxides, nitrogen oxides, hydrocarbons, and carbon monoxide are based on control levels expected necessary to meet national standards. Although final air emission control standards have not been established for refineries, a recent analysis of new refinery construction, [5] which emphasizes the most modern control equipment, indicates that air emissions of all pollutants (with the possible exception of hydrocarbons) can be controlled to meet Federal health standards. Hydrocarbons appear to be a particular problem because they are not emitted from specific points where they can be controlled but result from evaporation when oil contacts air. The study concluded that any point directly downwind from a refinery up to a distance of about 5 miles would most likely violate the current standard set by EPA to protect human health. The hydrocarbons are likely to be detected as odors, but not as strong odors. Hydrocarbons are potentially troublesome because they are a precursor of photochemical oxidants, which irritate mucous membranes, reduce resistance to respiratory infection, damage plants, and contribute to deterioration of materials.

Changes in water pollution effluents are shown by projecting biological oxygen demand (BOD) levels from both new and existing industries and municipalities. The BOD of a typical refinery would be equal to the discharge of a municipal treatment plant serving 2,000 people and using secondary treatment. Additional impacts on water quality would occur thermally. Noise levels, expected to increase from construction, are not addressed quantitatively in this report.

The impacts of OCS development on wildlife and vegetation depend largely upon the degree to which undeveloped land is developed, upon local attitudes toward conservation in general, and upon the degree to which there are laws and formal systems which protect vegetation and wildlife in the state, county, and municipality involved. Most vulnerable of habitats is the estuarine wetland—often used as a dump for dredged materials or solid waste, for farming, or for industry or homes. All these uses destroy the valuable wetland, but whenever less land is available for these uses, pressure increases to use wetlands and tidelands. Inland, population growth can encroach upon forest, old fields, and woodland as well as wetland habitat when it demands more highways, houses, shopping centers, etc.

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*The analyses in the RPA report develop per capita ratios for police, hospital, solid waste, and other services. The ratios are considered to remain constant as population increases due to OCS development. This assumption may not always be valid as a region changes from rural or agricultural to industrial, but the linear increases with population are a reasonable estimate of social impacts.

The projected impacts are briefly summarized for each region and local area in the sections that follow.

REGION AND AREA ANALYSES

New England

The New England area historically is an importer of petroleum products from other refining and gas processing centers. With current demand of about 1.2 million barrels per day, the area has virtually no refining, gas processing, or petrochemical facilities. The Bristol County area in southeastern Massachusetts, selected as a sample site, supports several light manufacturing industries but little heavy industry. Urban development is centered in New Bedford, Fall River, and Taunton. The area suffers higher than average unemployment rates. The eastern Massachusetts/Rhode Island region has about a 15 percent higher per capita income than Bristol County and includes the Boston and Providence metropolitan areas.

Under high OCS development conditions, a refining capacity of about 560,000 barrels per day would be required in 1985 (two to three average-size refineries) and of 1,120,000 barrels per day in 2000 (five to six average-size refineries). In addition, two gas processing plants and a small petrochemical plant could be expected in the New England area in 1985, and by 2000, New England could have eight gas processing plants and two to three petrochemical complexes to support high OCS development levels. Regional employment would increase by about 3 percent (80,000 new jobs in both 1985 and 2000) and value of output by 4 to 5 percent under the high impact case; under the low development scenario both employment and output would increase about 1 to 2 percent.

By 1985 almost 6,000 new construction jobs would be created in Bristol County (see Table 7-4). By 2000, construction employment would fall to one-third its 1985 level. Overall employment in Bristol County with

TABLE 7-4

Bristol County Aggregate Economic Impacts, High Development

Sector	1985	Percent over BC 1	Percent over BC 2	2000	Percent over BC 1	Percent over BC 2
Employment (thousands)						
Construction	5.9	59	59	2.0	14	14
Refining, gas processing, petrochemicals	.8	†	†	2.3	†	†
Other manufacturing	2.6	3	3	2.7	3	3
Agriculture	0	0	0	0	0	0
Utilities	.6	7	6	.7	7	7
Services	9.1	8	7	9.6	7	7
Total	19.0	9	9	17.3	7	7
Value of output ($ million)[1]						
Construction	196	54	54	78	13	13
Refining, gas processing, petrochemicals	481	†	†	1,168	†	†
Other manufacturing	97	3	3	139	3	3
Agriculture	0	0	0	0	0	0
Utilities	20	7	6	32	7	7
Services	175	8	7	231	7	7
Total	969	16	16	1,648	19	19

† = infinite percentage because base case is zero.

[1] All dollar figures are 1970 constant dollars.

Source: Resource Planning Associates, Inc., and David M. Dornbusch & Co., 1974, "Potential Onshore Effects of Oil and Gas Production on the Atlantic and Gulf of Alaska Outer Continental Shelves," prepared for the Council on Environmental Quality under contract No. EQ4AC002.

high OCS development would be about 7 to 9 percent above base case in both years. For the low impact case, the number of jobs would be about 2 to 3 percent above base case (about one-fourth the number created under the high development case). About 50 percent of all new jobs would be created in the service sector under either scenario. Economic output in Bristol County would rise about 16 to 19 percent under the high impact case. The major contributor to economic output is the refining sector (two to three average-size refineries in the county).

The high impact case would increase demands on physical and social systems over either base case in Bristol County by an average of nearly 9 percent in 1985 and 7 percent in 2000 (see Table 7-5). The low development case would increase demands by 3 percent and 2 percent for 1985 and 2000, respectively. Although in the aggregate this growth seems modest, for certain areas it is not. Land around the major urban areas is almost fully utilized, so that growth would probably occur in the smaller communities or through redevelopment of the older cities and downtowns. If two or three of the county's dozen communities of about 10,000 people were to receive a majority of the projected 44,000 new inhabitants, existing facilities would be significantly strained—particularly in Massachusetts, where over the years great efforts have been made to retain the traditional architecture and central commons in each small town. To the extent that such growth would occur in these smaller towns, they would

TABLE 7-5

Bristol County Social Infrastructure Impacts

	1970	1985				2000			
		Base Case 1	Base Case 2	Increase		Base Case 1	Base Case 2	Increase	
				High development	Low development			High development	Low development
Population (thousands)	440	500	506	43.6	15.1	550	557	38.8	12
Percent change[1]				8.7/8.6	3/2.9			7/6.9	2.2/2.1
Physical systems									
Water demand (million gallons per day)	60	85	86	7	3	104	106	7	2
Electricity demand (megawatt capacity)	NA	NA	NA	161	.9	NA	NA	371	4
Structures									
Residential (thousands)	142	160	162	14	5	176	178	12	4
Commercial (million square feet)	11	13.1	13.3	1.2	.4	14.4	14.6	1.0	.3
Social systems									
Schools — enrollees (thousands)	106	120	122	10	3	132	134	9	3
Hospitals — beds	1,658	1,865	1,887	164	56	2,051	2,078	145	45
Police — manpower	808	910	921	80	27	1,001	1,014	71	22
Solid waste (tons per day)	1,322	1,500	1,517	131	45	1,650	1,670	116	36
Sewage (million gallons per day)	53	60	61	5	2	66	67	5	1
Government overhead ($ million)	37.5	42.2	42.7	3.7	1.3	46.4	47.0	3.3	1.0
Business and government institutions									
Business services — employees (thousands)	49.4	55.8	56.1	4.8	1.7	61.5	61.8	4.3	1.3
Government employees (thousands)	13.0	14.8	14.9	1.3	.5	16.3	16.4	1.1	.4

[1] The percentage changes are indicated as follows: Impact Case divided by Base Case 1/Impact Case divided by Base Case 2.

Source: Resource Planning Associates, Inc., and David M. Dornbusch & Co., 1974, "Potential Onshore Effects of Oil and Gas Production on the Atlantic and Gulf of Alaska Outer Continental Shelves," prepared for the Council on Environmental Quality under contract No. EQ4AC002.

have to plan, zone, expand services, and make complex development decisions. Instead, special efforts could be made to locate residential and commercial development in the decaying centers of the old cities of New Bedford and Fall River. To achieve this would take a substantial regional planning and regulatory program.

There are a number of important areas of wildlife and vegetation in Bristol County. Over 30,000 acres of wetlands is found in the county, roughly 10 percent along the coast. The more important areas are Acushet Cedar Swamp, Hookomook Swamp, Freetown-Fall River State Forest and Wildlife Management Area, and the Bungay River National Fish Hatchery. Rare and endangered species include the osprey, Atlantic salmon, Atlantic sturgeon, and Ipswich sparrow.

Although at both the local and regional levels, there appears a substantial amount of undeveloped land, under the high impact case combined with Base Case 2 (the most land-intensive situation), 9 percent of regional undeveloped land and 14 percent of suitable land for general development would be required. This finding suggests possible difficulties in locating sites for primary development (specialized and heavy industry uses). Further, as noted earlier, local and state laws against development of wetlands and an active public interest in protecting water resources, special habitats, timber-producing lands, recreation and scenic areas, and valuable agricultural land must also be considered. In addition, substantial portions of open land have been set aside for low-density residential use. When all these constraints are taken into account, the amount of land is reduced, and OCS requirements increase to 17 percent of this new lower total land available.

Figures 7-3 through 7-5 put these findings into perspective for the New England region. Figure 7-3 shows currently developed land, Figure 7-4 shows the land available for general development[*] after consideration of environmental constraints, and Figure 7-5 shows the land suitable for primary development after consideration of industrial locational constraints. The figures would seem to indicate that sections of Bristol County and the inland part of Plymouth County have suitable land available for both general and primary development, but the scale used in the figures does not distinguish small parcels of land, low-density residential development, and possible water resource areas. With Cape Cod recreationally important to the economic and social health of the state and the region, it is logical that coastal development should be avoided. Furthermore, suitable inland sites exist in communities that actively desire primary industry. Thus the locational analysis in this region will focus on ways to get oil and gas from the OCS to inland sites.

Air pollution levels within Bristol County and the region vary among pollutants. Both county and region are classified Priority I[†] for particulates, sulfur oxides, and nitrogen oxides and Priority III for other pollutants. The impact under high OCS production is significant for hydrocarbons—17 times higher than without OCS production—mainly from refineries. The hydrocarbon emissions could have health effects in areas near the refineries. For all other air pollutants, overall emissions should remain at about 1972 levels, assuming application of emission controls. Carbon monoxide and hydrocarbon emissions are expected to decrease under base case assumptions because of auto emission and other controls.

With respect to water quality, current levels of BOD in Bristol County and the region result primarily from paper mill and municipal sewage plant discharges. BOD levels are expected to decrease substantially under each base case with application of effluent controls, but they could increase about 23 percent under high OCS development (see Figure 7-6). For the region, OCS production could increase BOD about 5 percent over the base case due mainly to additional industrial and municipal sources.

Middle Atlantic

The Delaware River region chosen for analysis is a belt of urban counties from Wilmington, Del., north to the New Jersey suburbs of New York City and rural southern New Jersey. It contains the entire 1.4 million barrels per day refining capacity of the Mid-Atlantic states. The densely populated region has a varied industry base, from heavy manufacturing to light service industries and agriculture.

Cumberland and Cape May Counties are about halfway between Washington, D.C., and New York City and about 60 miles southeast of Philadelphia. The area is relatively rural and contains no refineries or petrochemical plants. Agriculture and manufacturing are important economic contributors in the small towns and villages of Cumberland County, and the resort

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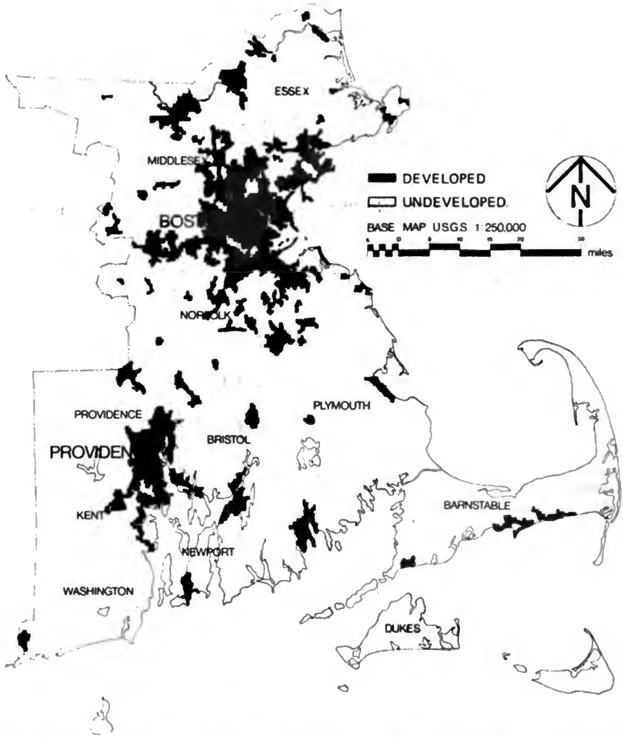
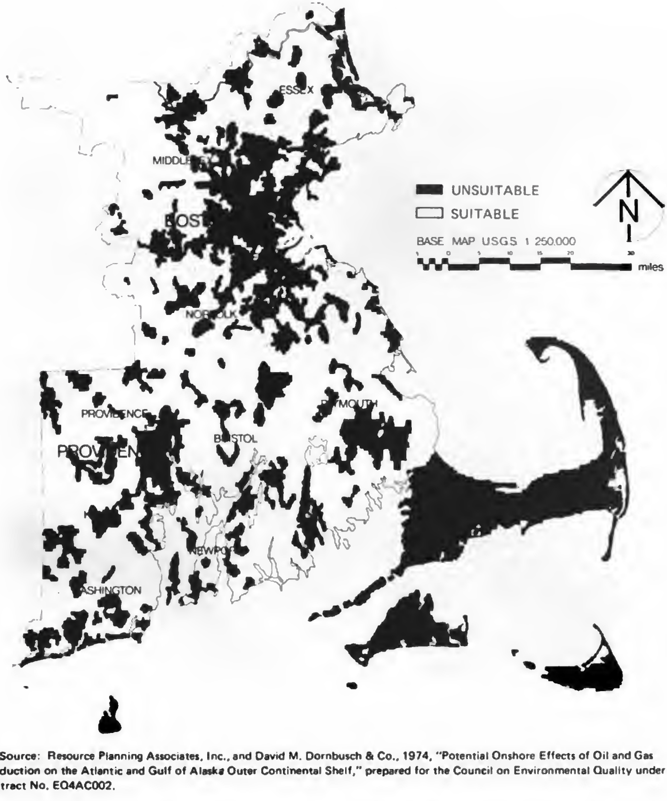
[*] General development includes residential, commercial, industrial, and agricultural uses. Primary development includes specialized and heavy industrial uses (e.g., refineries).

[†] Air pollution regions are defined by EPA as having air quality that is either Priority I, Priority II, Priority III, or Priority IV; Priority I is the lowest quality and IV is the highest.



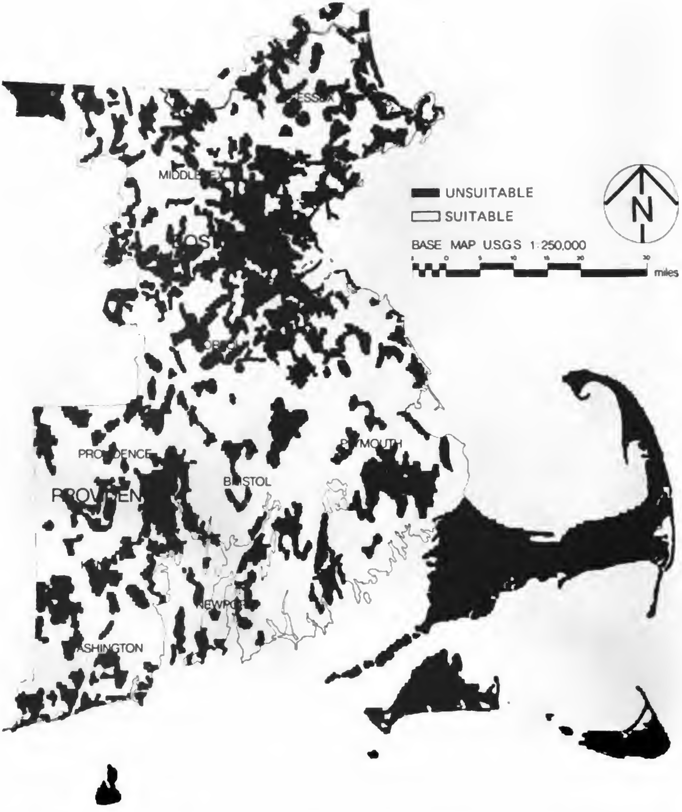
Source: Resource Planning Associates, Inc., and David M. Dornbusch & Co., 1974, "Potential Onshore Effects of Oil and Gas Production on the Atlantic and Gulf of Alaska Outer Continental Shelf," prepared for the Council on Environmental Quality under contract No. EQ4AC002.

Figure 7-3. Eastern Massachusetts/Rhode Island Land, Developed and Undeveloped



Source: Resource Planning Associates, Inc., and David M. Dornbusch & Co., 1974, "Potential Onshore Effects of Oil and Gas Production on the Atlantic and Gulf of Alaska Outer Continental Shelf," prepared for the Council on Environmental Quality under contract No. EQ4AC002.

Figure 7-4. Eastern Massachusetts/Rhode Island Land Suitable for General Development

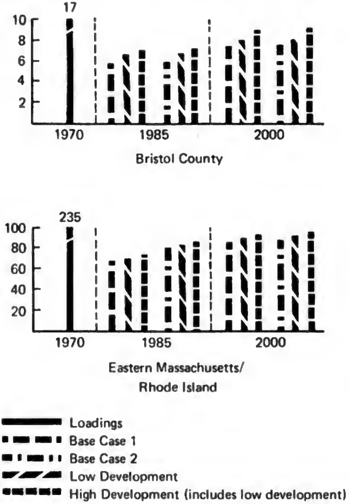


Source: Resource Planning Associates, Inc., and David M. Dornbusch & Co., 1974, "Potential Onshore Effects of Oil and Gas Production on the Atlantic and Gulf of Alaska Outer Continental Shelf," prepared for the Council on Environmental Quality under contract No. EQ4AC002.

Figure 7-5. Eastern Massachusetts/Rhode Island Land Suitable for Primary Development

industry is a major employer in Cape May County, which has extensive Atlantic beaches as well as shoreline on Delaware Bay. Both counties contain extensive coastal wetlands which are biologically valuable and serve as prime nesting and feeding areas for waterfowl. Both have oyster industries that are making a comeback, and the improving water quality of Delaware Bay provides both with substantial opportunities for future recreational development.

A refining capacity of about 840,000 barrels per day (four to five refineries), 1 billion cubic feet per day of gas processing (about two plants), and two petrochemical complexes could be needed in the region by 1985 to support high OCS development assumptions. Similarly, about 1.5 million barrels per day of refining capacity (seven to eight refineries), 4 million cubic feet per day of gas processing (eight plants), and six petrochemical complexes may be needed in 2000. Much of this development is likely to take place in Cumberland and Cape May Counties.



Source: Resource Planning Associates, Inc., and David M. Dornbusch & Co., 1974, "Potential Onshore Effects of Oil and Gas Production on the Atlantic and Gulf of Alaska Outer Continental Shelves," prepared for the Council on Environmental Quality under contract No. EQ4AC002.

Figure 7-6. New England BOD Loadings
(Thousand tons per year)

The 30,000 new jobs created under the high OCS development scenario as applied to the two-county area represents about a 20 percent increase over Base Case 2 and a 30 percent increase over Base Case 1 (see Table 7-6). Low OCS development would create about 9,000 new jobs. Under the high development case the jobs created would be evenly distributed to construction, refining, and petrochemicals in 1985, but in 2000, the refining and petrochemical sectors would each account for about 50 percent of primary and induced jobs. Increased local economic output of 26 to 56 percent under low and high development, respectively, could be very significant in an area that has been economically stagnant.

Although local economic impacts in Cape May and Cumberland Counties may be large, regional effects would be considerably less because the region of which these two rural counties are a part is highly urban and industrial. Employment under the high development case would increase by about 120,000 in the year 2000 and 100,000 in 1985, but these increases are only 2 percent over base cases (see Table 7-7). The region is already heavily populated, and the employment and economic output changes would make but a small dent. Skilled labor should be available to the primary industries.

Offshore production could exert extreme development pressures in Cumberland and Cape May Counties. If a deepwater terminal were constructed and OCS development were large scale, they could grow 108 percent over the 1970 level, as shown in Table 7-8. Such growth would shift the area economy from tourism, fishing, and agriculture and would place great strain on public facilities, particularly schools, hospitals, and water supplies. New public facilities would be needed on a large scale. For example, under the OCS high impact and Base Case 2, 50,000 more students in 1985 would require at least 10 new high schools.

Because there are no large cities, the major growth impact would be felt by the small towns and fishing villages, which would probably be overrun with new development. Although most of the towns would welcome some economic growth, many are already experiencing a comeback from a healthier oyster industry

TABLE 7-6

Cumberland/Cape May Counties Aggregate Economic Impacts, High Development

Sector	1985	Percent over BC 1	Percent over BC 2	2000	Percent over BC 1	Percent over BC 2
Employment (thousands)						
Construction	3.6	119	35	1.2	31	19
Refining, gas processing, petrochemicals	2.9	†	38	3.9	†	35
Other manufacturing	5.3	13	11	6.2	14	12
Agriculture	•	1	1	•	1	1
Utilities	2.0	51	26	2.6	53	30
Services	15.0	32	21	18.0	33	23
Total	28.8	30	19	31.9	29	20
Value of output ($ million)[1]						
Construction	118	115	35	47	29	18
Refining, gas processing, petrochemicals	921	†	43	1,454	†	41
Other manufacturing	213	13	11	344	14	12
Agriculture	1	1	1	2	1	1
Utilities	68	51	26	114	53	30
Services	276	32	21	409	33	23
Total	1,597	57	26	2,370	56	26

• = negligible.

† = infinite percentage because base case is zero.

[1] All dollar figures are 1970 constant dollars.

TABLE 7-7

Delaware River Region Aggregate Economic Impacts, High Development

Sector	1985	Percent over BC 1	Percent over BC 2	2000	Percent over BC 1	Percent over BC 2
Employment (thousands)						
Construction	10.1	4	4	3.5	1	1
Refining, gas processing, petrochemicals	6.2	67	27	11.5	123	48
Other manufacturing	18.2	2	1	22.3	2	2
Agriculture	.3	2	2	.3	2	2
Utilities	6.4	3	3	9.0	4	4
Services	59.0	2	2	74.2	2	2
Total	100.2	2	2	120.8	2	2
Value of output ($ million)[1]						
Construction	334	3	3	134	1	1
Refining, gas processing, petrochemicals	1,963	48	26	4,028	71	42
Other manufacturing	883	2	1	1,478	2	2
Agriculture	10	2	1	16	2	2
Utilities	255	3	3	460	4	4
Services	1,279	2	2	2,024	2	2
Total	4,724	3	3	8,140	4	4

[1] All dollar figures are 1970 constant dollars.

Source: Resource Planning Associates, Inc., and David M. Dornbusch & Co., 1974, "Potential Onshore Effects of Oil and Gas Production on the Atlantic and Gulf of Alaska Outer Continental Shelves," prepared for the Council on Environmental Quality under contract No. EQ4AC002.

and from city residents buying second homes. Many of the towns date from early settlement along the bay, and care would have to be taken to assure that development did not destory these historical resources and the physical character of the towns. Present land use regulations provide no such assurances.

RPA's spatial analysis indicates that the undeveloped land available in Cumberland and Cape May Counties is not well suited for location of primary industries on a large scale. High OCS development under Base Case 2 would reduce undeveloped land from 79 percent to 52 percent in the local area. Land requirements for commercial and industrial purposes would nearly triple by the year 2000 under this case (it would increase only 15 percent under Base Case 1 development without OCS production). Most of Cape May County and coastal Cumberland County is unavailable or unsuitable for primary development because of extensive beaches, salt marshes, and recreational lands (see Figures 7-7 and 7-8). However, northern Cumberland, Salem, and Gloucester Counties, which are already partially industrial as part of the Delaware Valley complex, may have land available for additional growth at existing and new sites. Refineries and other primary industry may also locate at existing industrial centers around Philadelphia and in northern New Jersey.

TABLE 7-8

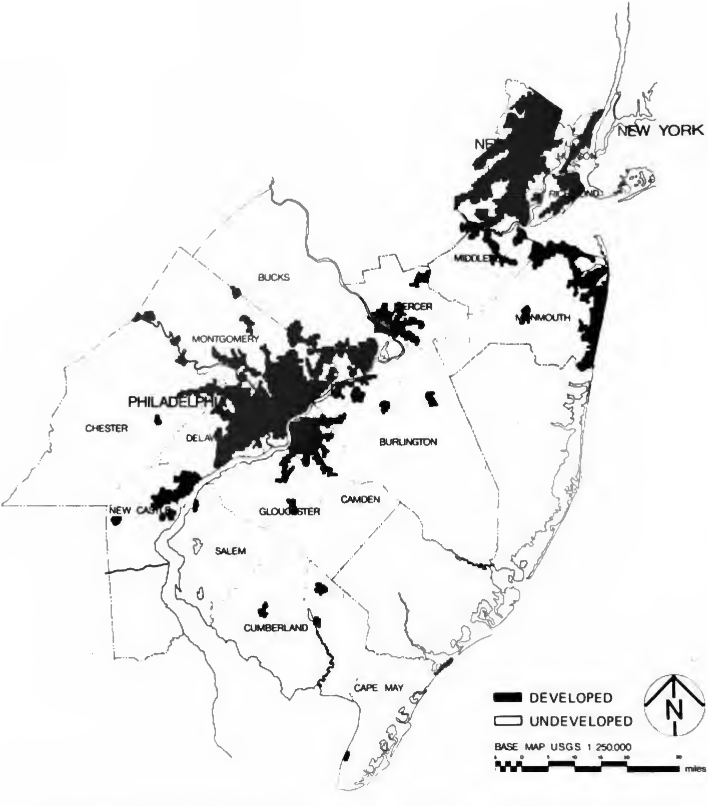
Cumberland/Cape May Counties Social Infrastructure Impacts[1]

	1970	1985				2000			
		Base Case 1	Base Case 2	Increase		Base Case 1	Base Case 2	Increase	
				High development	Low development			High development	Low development
Population (thousands)	181	219	318	59.6	17.9	258	354	66.0	18.4
Percent change[2]				27/19	8/6			26/19	7/5
Physical systems									
Water demand (million gallons per day)	27	37	54	10	3	49	67	13	3
Electricity demand (megawatt capacity)	NA	NA	NA	367	130	NA	NA	587	140
Structures									
Residential (thousands)	58	70	102	19	6	83	113	21	6
Commercial (million square feet)	4.3	5.7	8.3	1.6	.5	6.7	9.3	1.7	.5
Social systems									
Schools – enrollees (thousands)	45	54	79	15	4	64	89	17	4
Hospitals – beds	614	742	1,078	203	61	875	1,200	224	61
Police – manpower	340	412	598	113	34	485	666	124	34
Solid waste (tons per day)	543	657	953	179	54	774	1,062	198	55
Sewage (million gallons per day)	22	26	38	7	2	31	42	8	2
Government overhead ($ million)	18.0	21.8	31.6	5.9	1.8	25.7	35.2	6.6	1.8
Business and government institutions									
Business services – employees (thousands)	16.9	20.2	29.2	5.5	1.6	23.8	32.5	6.0	1.7
Government employees (thousands)	5.3	6.1	9.0	1.7	.5	7.6	10.3	1.9	.5

[1] Some factors used in estimating per capita needs for services would change as the area's character changes. The impacts may be overstated for some services, but they are probably good approximations.

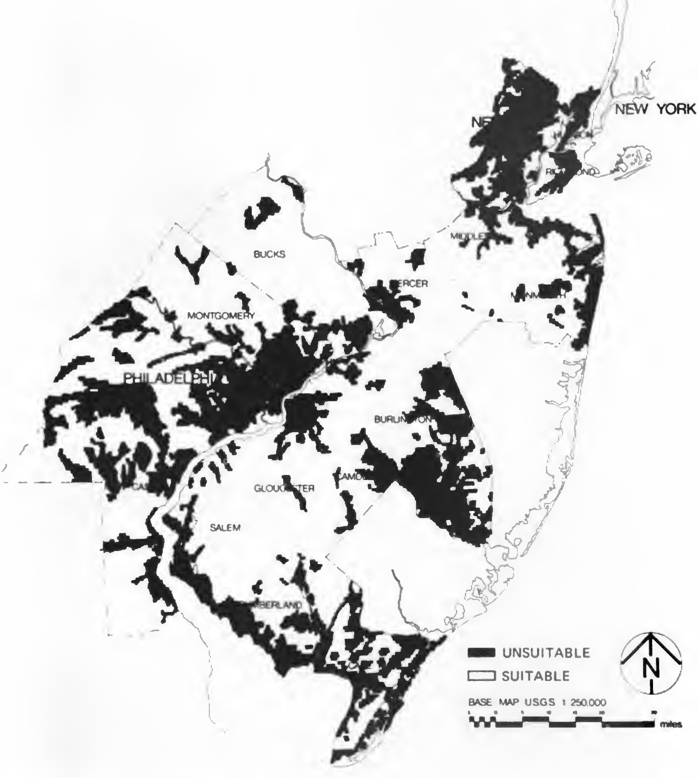
[2] The percentage changes are indicated as follows: Impact Case divided by Base Case 1/Impact Case divided by Base Case 2.

Source: Resource Planning Associates, Inc., and David M. Dornbusch & Co., 1974, "Potential Onshore Effects of Oil and Gas Production on the Atlantic and Gulf of Alaska Outer Continental Shelves," prepared for the Council on Environmental Quality under contract No. EQ4AC002.



Source: Resource Planning Associates, Inc., and David M. Dornbusch & Co., 1974, "Potential Onshore Effects of Oil and Gas Production on the Atlantic and Gulf of Alaska Outer Continental Shelf," prepared for the Council on Environmental Quality under contract No. EQ4AC002.

Figure 7-7. Delaware River Region Land, Developed and Undeveloped



Source: Resource Planning Associates, Inc., and David M. Dornbusch & Co., 1974, "Potential Onshore Effects of Oil and Gas Production on the Atlantic and Gulf of Alaska Outer Continental Shelf," prepared for the Council on Environmental Quality under contract No. EQ4AC002.

Figure 7-8. Delaware River Region Land Suitable for Primary Development

Other environmental problems are associated with locating primary industry in Cape May and Cumberland Counties. Here are some of the most important wetlands in the Mid-Atlantic region, the prime nesting and feeding areas for the ducks and geese of the Atlantic flyway. Of the over 100,000 acres considered wetlands, 99 percent is rated of high value for waterfowl. The New Jersey state government has been especially active in trying to protect and preserve these wetlands. Among the major areas are the Dennis Creek and Heislerville Egg Island Wildlife Management Areas, World Wildlife Fund South Jersey Wetlands, and several fishing areas. Additional valuable coastal areas are found in other parts of the Delaware River region.

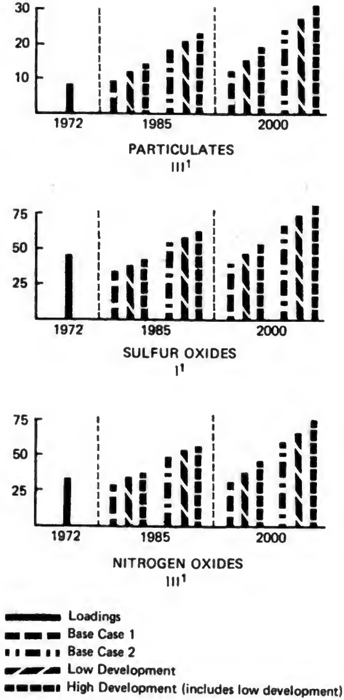
Most air emissions under Base Case 1 are expected to increase moderately or to decrease in the local area. The growth of refineries and petrochemical plants under Base Case 2 would increase hydrocarbon emissions significantly. Air pollution as a result of high OCS production could be substantial in local areas (see Figure 7-9). BOD loadings under Base Case 2 would increase by about 50 percent, but under Base Case 1 and high OCS production, BOD levels would remain about the same as 1970.

Because of the high level of industrial development projected for this region, the impact of primary industry effluents on the water quality of the Delaware River and Bay was analyzed. Mathematical modeling was used to determine changes in dissolved oxygen (DO) levels in the river as a result of new refineries and petrochemical plants at specific locations on the river. Assuming use of best available water treatment technology, the new refineries and petrochemical plants will have a relatively small impact on DO levels.

Eastern South Carolina/Eastern Georgia

South Carolina's Charleston, Dorchester, and Berkeley Counties are an area that supports farming and is characterized by large wetland and forested areas. Urban land is concentrated primarily on the Charleston peninsula, where preservation of the historic old town and associated historic and tourist sites nearby has been extensive. The service sector employs 71 percent of the area work force, and manufacturing accounts for 16 percent. There are no refineries in the area. The average per capita income is below the national average.

Under high OCS development assumptions, the region would require approximately three refineries, two



¹EPA Air Quality Priority Classification

Source: Resource Planning Associates, Inc., and David M. Dornbusch & Co., 1974, "Potential Onshore Effects of Oil and Gas Production on the Atlantic and Gulf of Alaska Outer Continental Shelves," prepared for the Council on Environmental Quality under contract No. EQ4AC002.

Figure 7-9. Cumberland/Cape May Counties Air Pollution (Thousand tons per year)

gas processing plants, and two to three petrochemical complexes in 1985; in 2000, five to six refineries, eight gas processing plants, and seven to eight petrochemical complexes would be needed. About half of this primary development is projected for the local area.

In the region, 88,000 new jobs would be generated in 1985 and 110,000 in 2000, representing 20 to 25 percent increases over the base case. Low OCS development in the region would account for about 20,000 new jobs, or 3 to 5 percent increases. The Charleston area would experience a growth of 59,000 new jobs (see Table 7-9). Under the low development case added employment is 13,000 and 14,000 for 1985 and 2000, respectively. The high impacts, both on an absolute and on a percentage basis, are larger than in any other east coast locality. Because Charleston is the only major metropolitan area within the region and most of the induced and service activity would probably locate near the city, there are special problems of concentration of development in this area.

OCS oil and gas production could substantially change the social infrastructure locally. Under Base Case 2 and high OCS conditions, the population would almost double between 1970 and 1985 (336,000 to 650,000), with about one-half the increase due to Base Case 2 growth (see Table 7-10)—the equivalent of building a new city the size of Charleston in about a decade. New powerplants, offices, schools, and hospitals would have to be planned and constructed. The projected 37,000 new dwelling units could require about $1 billion in mortgage financing, and with money also being needed for industrial support, capital availability could be a problem.

At both the local and regional levels, there appears enough undeveloped land for both base case and OCS-related development. Land requirements are less severe than for the New England or Mid-Atlantic regions (see Figures 7-10 and 7-11). About 95 percent of the land is undeveloped, and even after environmental and locational constraints are considered, about 2.3 million acres would remain available (high OCS and Base Case 2 growth would require about 240,000 acres). The areas with most suitable land are in Orangeburg and Clarendon Counties. Additional land may be available in Charleston, Chatham, and Jasper Counties.

Development of this magnitude, however, if allowed to proceed without land use controls, could severely degrade the environment through unnecessary loss of

TABLE 7-9

Charleston Aggregate Economic Impacts, High Development

Sector	1985	Percent over BC 1	Percent over BC 2	2000	Percent over BC 1	Percent over BC 2
Employment (thousands)						
Construction	6.9	63	57	2.4	17	16
Refining, gas processing, petrochemicals	3.0	†	555	7.2	†	1,199
Other manufacturing	14.3	56	34	19.2	51	33
Agriculture	.1	2	2	.1	3	3
Utilities	3.9	30	22	6.1	38	27
Services	31.0	33	25	40.8	32	24
Total	59.2	41	29	75.8	38	28
Value of output ($ million)[1]						
Construction	228	65	59	91	17	17
Refining, gas processing, petrochemicals	793	†	241	2,052	†	416
Other manufacturing	581	55	34	1,062	51	33
Agriculture	2	2	2	4	3	3
Utilities	154	30	22	310	38	27
Services	648	33	25	1,063	32	24
Total	2,406	61	41	4,582	66	46

† = infinite percentage because base case is zero.

[1] All dollar figures are 1970 constant dollars.

Source: Resource Planning Associates, Inc., and David M. Dornbusch & Co., 1974, "Potential Onshore Effects of Oil and Gas Production on the Atlantic and Gulf of Alaska Outer Continental Shelves," prepared for the Council on Environmental Quality under contract No. EQ4AC002.

TABLE 7-10

Charleston Social Infrastructure Impacts

	1970	1985				2000			
		Base Case 1	Base Case 2	Increase		Base Case 1	Base Case 2	Increase	
				High development	Low development			High development	Low development
Population (thousands)	336	400	512.8	137.5	32.7	476	595.6	145.4	27.2
Percent change[1]				34/27	8/6			31/24	6/5
Physical systems									
Water demand (million gallons per day)	50.4	68	87	23	6	90	113	28	5
Electricity demand (megawatt capacity)	NA	NA	NA	491	108	NA	NA	1,107	164
Structures									
Residential (thousands)	91	108	139	37	9	129	161	39	7
Commercial (million square feet)	8.2	9	11.5	3.1	.7	10.7	13.4	3.3	.6
Social systems									
Schools – enrollees (thousands)	97	116	149	40	10	138	173	42	7
Hospitals – beds	1,248	1,528	1,960	527	126	1,818	2,227	554	103
Police – manpower	327	388	498	134	32	462	578	141	26
Solid waste (tons per day)	1,008	1,200	1,538	412.5	98.1	1,428	1,787	436.2	81.6
Sewage (million gallons per day)	40.3	48	62	17	4	57	72	17	3
Government overhead ($ million)	14.0	16.8	21.5	5.8	1.4	19.9	24.9	6.1	1.1
Business and government institutions									
Business services – employees (thousands)	31.4	36.8	47.1	12.6	3.0	43.8	54.8	13.4	2.5
Government employees (thousands)	8.8	10.7	13.7	3.7	.9	12.7	15.9	3.9	.7

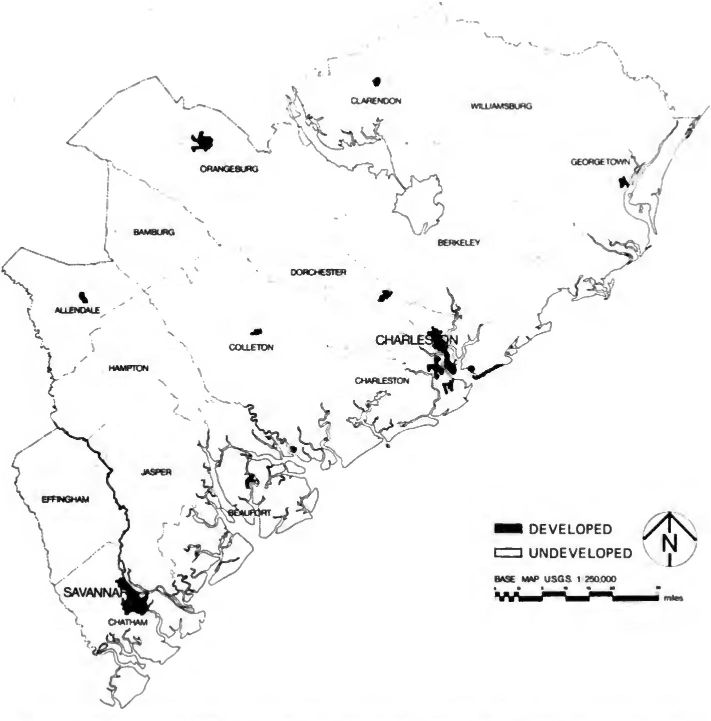
[1] The percentage changes are indicated as follows: Impact Case divided by Base Case 1/Impact Case divided by Base Case 2.

Source: Resource Planning Associates, Inc., and David M. Dornbusch & Co., 1974, "Potential Onshore Effects of Oil and Gas Production on the Atlantic and Gulf of Alaska Outer Continental Shelves," prepared for the Council on Environmental Quality under contract No. EQ4AC002.

wetlands and other important natural areas to residential, commercial, and industrial construction. Only major new initiatives would prevent low-density suburban sprawl and stop commercial development from causing widespread blight, particularly in areas noted for their old mansions, estates, and gardens that are open to the public.

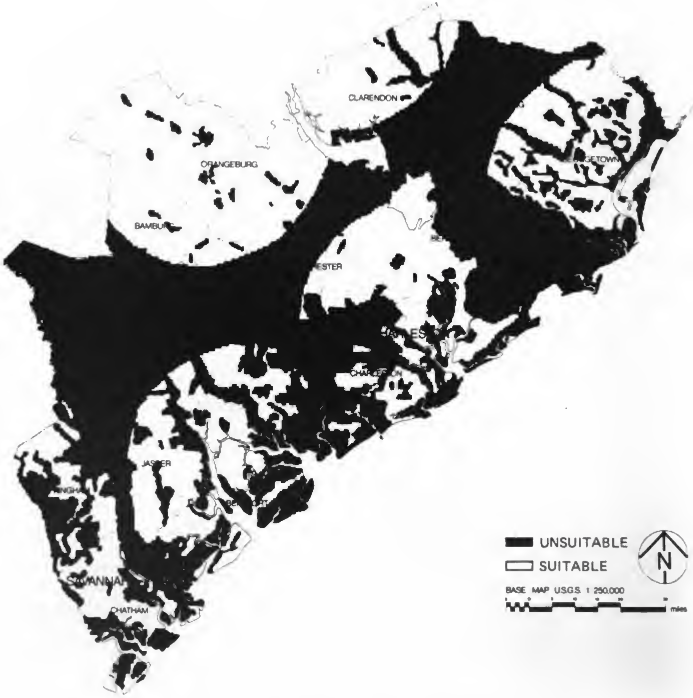
A special problem would face Charleston, where in recent years numerous battles have been won to preserve the past and to bar high rise construction and other development not in keeping with the historic character of the district. Furthermore, poorly sited industrial facilities, for example, could ruin the views from old town to Fort Sumter and other historic landmarks. Commercial development pressures for space downtown will be felt—the question is whether Charleston can provide for this economic growth in its urban core, where it is needed, without damaging its most valued historic resources.

Within the area are many wildlife refuges, forests, and wetlands (see Figure 7–12). The Francis Marion National Forest and the Santee and Cape Romain National Wildlife Refuges provide nesting and wintering habitat for hundreds of thousands of migratory waterfowl. The forest covers about 250,000 acres in Berkeley County and also provides habitat for Eastern wild turkey and white-tailed deer. Its swampy areas contain the endangered American alligator. Over 30 rare or endangered species live in these refuges at various times of the year, including the Southern bald eagle, Eastern



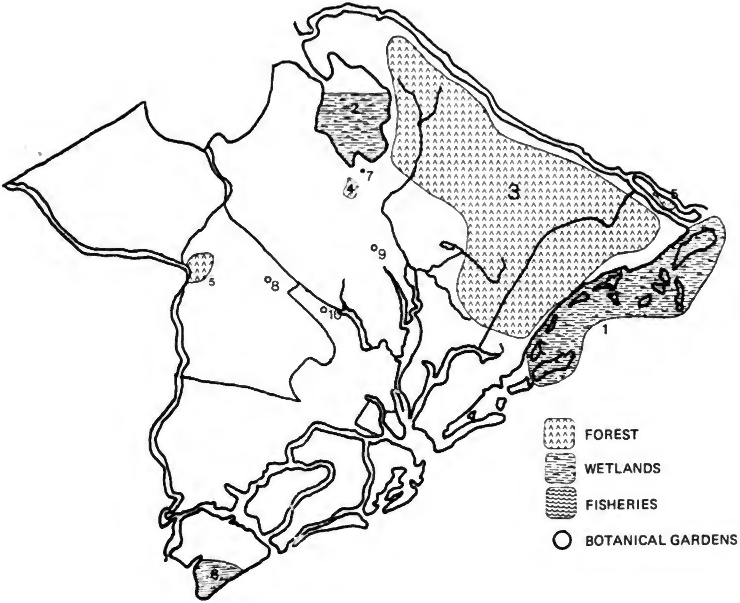
Source: Resource Planning Associates, Inc., and David M. Dornbusch & Co., 1974, "Potential Onshore Effects of Oil and Gas Production on the Atlantic and Gulf of Alaska Outer Continental Shelf," prepared for the Council on Environmental Quality under contract No. EQ4AC002.

Figure 7-10. Eastern South Carolina/Eastern Georgia Land, Developed and Undeveloped



Source: Resource Planning Associates, Inc., and David M. Dornbusch & Co., 1974, "Potential Onshore Effects of Oil and Gas Production on the Atlantic and Gulf of Alaska Outer Continental Shelf," prepared for the Council on Environmental Quality under contract No. EQ4AC002.

Figure 7-11. Eastern South Carolina/Eastern Georgia Land Suitable for Primary Development



1. Cape Romain National Wildlife Refuge
2. Santee National Wildlife Refuge
3. Francis Marion National Forest and State Wildlife Management Area
4. Hartley Game Management Area
5. Santee-Delta Game Management Area
6. Edisto Beach State Park Waterfowl Management Area
7. Moncks Corner State Fish Hatchery
8. Middletown Gardens
9. Cypress Gardens
10. Magnolia Gardens

Source: Resource Planning Associates, Inc., and David M. Dornbusch & Co., 1974, "Potential Onshore Effects of Oil and Gas Production on the Atlantic and Gulf of Alaska Outer Continental Shelf," prepared for the Council on Environmental Quality under contract No. EQ4AC002.

Figure 7-12. Charleston, S.C., Wildlife and Vegetation Areas

brown pelican, and Eskimo curlew. There are also several old botanical gardens, as well as populations of landlocked striped bass.

Air pollution impacts could be relatively more significant than in the New England and Mid-Atlantic areas. High OCS impacts would range up to 50 percent over Base Case 2 in the year 2000. Nevertheless, total hydrocarbon emissions would be less in 2000 than in 1972, assuming emission controls for mobile sources. Particulates and sulfur oxides would exhibit absolute increases over 1972 levels.

Water pollution would increase. Projected BOD loadings under high OCS production could approximately double current levels due to petrochemical and refining development.

Northeastern Florida/Southeastern Georgia

The five-county Jacksonville area in northeastern Florida lies 300 miles north of Miami and 200 miles southwest of Charleston. Jacksonville is the only major urban area in the region and has a population of 600,000. The region contains extensive coastal salt marshes and heavily used beaches. The service sector accounts for almost three-fourths of Jacksonville's employment; most of the work force is employed in government, finance, and insurance.

Assuming high OCS production levels, one to two refineries and two gas processing plants would be built by 1985. No incremental petrochemical development is assumed in 1985, because significant growth is expected in the South Atlantic area under Base Case 2. In 2000, about four refineries, eight gas processing plants, and six petrochemical complexes would be needed to support high OCS development.

Under high development conditions, 37,000 new jobs are projected in the Jacksonville area in 1985 (about 10 percent over both base cases) and 59,000 in 2000 (13 percent) (see Table 7-11). The low OCS development case would create about 10,000 new jobs under both scenarios (2 to 3 percent). The percentage increases in employment are lower than in Charleston, and availability of labor should not be a major problem although specific skills may be in short supply. Regional impacts would be about the same as local, with about 54,000 new jobs (11 to 12 percent over base cases) in 1985 and 85,000 new jobs (14 to 16 percent) in 2000 under high OCS development.

TABLE 7-11

Jacksonville Aggregate Economic Impacts, High Development

Sector	1985	Percent over BC 1	Percent over BC 2	2000	Percent over BC 1	Percent over BC 2
Employment (thousands)						
Construction	8.2	37	32	3.3	11	10
Refining, gas processing, petrochemicals	.9	†	158	7.2	†	162
Other manufacturing	7.0	13	12	12.9	22	18
Agriculture	.1	3	3	.1	2	2
Utilities	2.0	5	5	4.5	9	9
Services	18.8	7	7	30.7	10	9
Total	37.0	10	9	58.7	13	12
Value of output ($ million)[1]						
Construction	271	33	28	108	8	8
Refining, gas processing, petrochemicals	486	†	147	2,064	†	172
Other manufacturing	331	13	12	831	22	18
Agriculture	1	3	3	3	2	2
Utilities	75	5	5	222	9	9
Services	408	7	7	833	10	9
Total	1,572	15	14	4,061	25	21

† = infinite percentage because base case is zero.

[1] All dollar figures are 1970 constant dollars.

Source: Resource Planning Associates, Inc., and David M. Dornbusch & Co., 1974, "Potential Onshore Effects of Oil and Gas Production on the Atlantic and Gulf of Alaska Outer Continental Shelves," prepared for the Council on Environmental Quality under contract No. EQ4AC002.

Even under low growth baseline projections, the Jacksonville area population should increase from 660,000 in 1970 to 915,000 in 1985. Base Case 2 would add 5 percent to Base Case 1, high OCS development would add another 9 percent, and low development would add 3 percent (see Table 7-12). Instead of requiring major new service activities, Jacksonville may well expand existing or planned facilities to meet new demands created by OCS development.

Undeveloped land in this region appears adequate, especially inland. On a percentage basis, the region as a whole is less developed than the Jacksonville locale. Much undeveloped land is not available because of environmental values. There is about 1.8 million remaining developable acres, which is almost nine times the 207,000 acres required for Base Case 2 and high OCS development (see Figures 7-13 and 7-14).

The five-county local area contains about 725,000 acres of wetlands, of which the Florida Coastal Coordinating Council has designated 60,000 acres of coastal marsh and 58,000 acres of freshwater swamp and marsh as important to the propagation of marine life, the habitat of waterfowl and wading birds, or the ecology of the area in general. The coastal wetlands selected are concentrated primarily in Nassau and Duval Counties. Inland in Baker County are the huge Okefenokee Swamp and National Wildlife Refuge as well as much of Osceola National Forest. Both support the American alligator and various other bay and swamp dwellers. The region also contains large wetlands areas along the coast of Georgia.

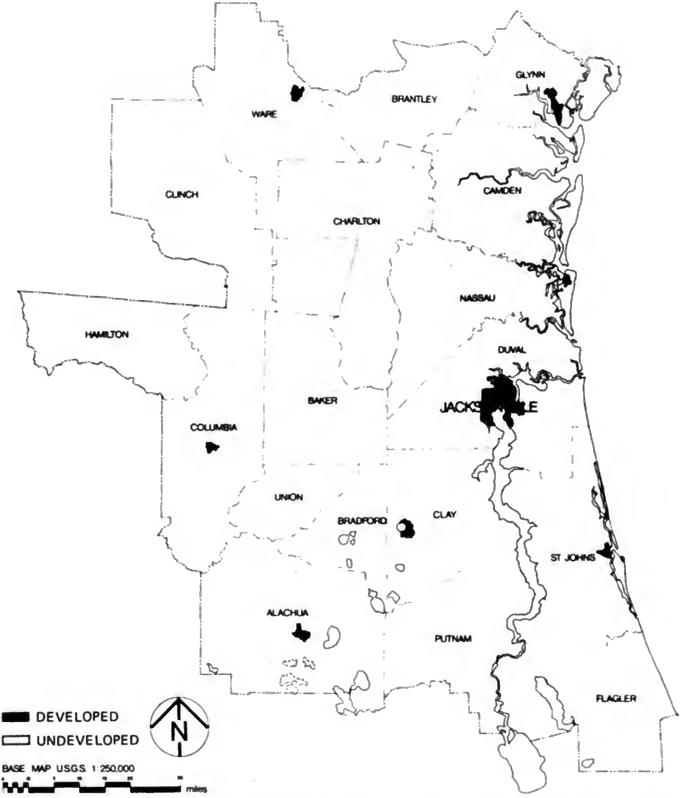
TABLE 7-12

Jacksonville Social Infrastructure Impacts

	1970	1985				2000			
		Base Case 1	Base Case 2	Increase		Base Case 1	Base Case 2	Increase	
				High development	Low development			High development	Low development
Population (thousands)	622	915	965	82.3	23.7	1,069	1,150	111.2	17.5
Percent change[1]				9/8.5	3/2.5			10.4/9.7	1.6/1.5
Physical systems									
Water demand (million gallons per day)	93.3	156	164	14	4	203	218	21	3
Electricity demand (megawatt capacity)	NA	NA	NA	245	99	NA	NA	1,030	142
Structures									
Residential (thousands)	187	274	289	25	7	321	345	33	5
Commercial (million square feet)	15.6	22.9	24.1	2.0	.6	26.7	28.8	2.8	.5
Social systems									
Schools – enrollees (thousands)	168	247	260	23	7	289	310	30	4
Hospitals – beds	2,303	3,385	3,570	303	89	3,955	4,255	411	67
Police – manpower	908	1,336	1,409	120	35	1,561	1,679	162	26
Solid waste (tons per day)	1,866	2,745	2,894	247	71	3,207	3,450	334	53
Sewage (million gallons per day)	74.6	110	116	10	3	128	138	13	2
Government overhead ($ million)	47.6	70.2	74.1	6.3	1.8	82.1	88.3	8.5	1.4
Business and government institutions									
Business services – employees (thousands)	127.4	186.7	196.7	16.7	4.8	218.1	234.6	22.7	3.6
Government employees (thousands)	20.4	29.9	31.5	2.7	.8	34.9	37.6	3.6	.6

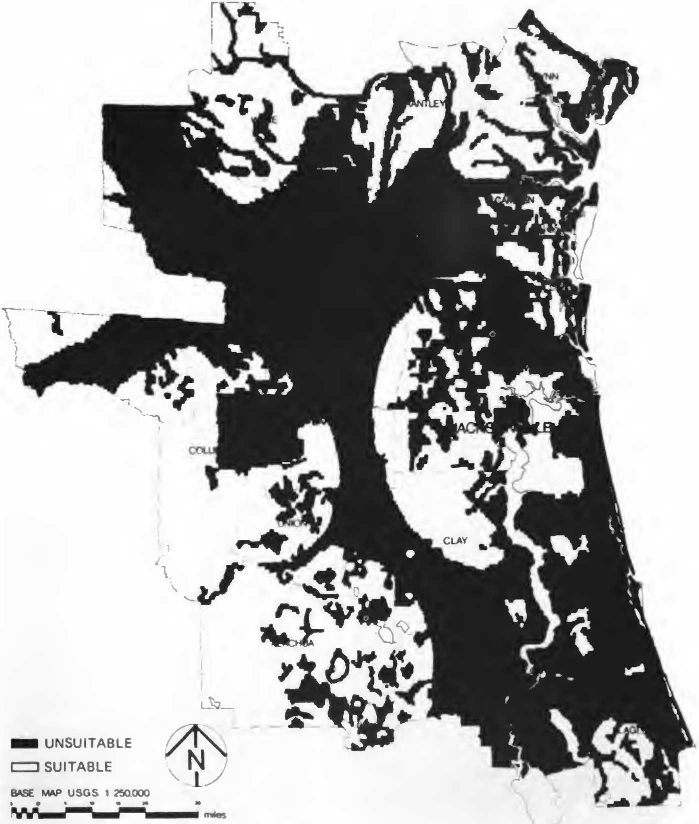
[1] The percentage changes are indicated as follows: Impact Case divided by Base Case 1/Impact Case divided by Base Case 2.

Source: Resource Planning Associates, Inc., and David M. Dornbusch & Co., 1974, "Potential Onshore Effects of Oil and Gas Production on the Atlantic and Gulf of Alaska Outer Continental Shelves," prepared for the Council on Environmental Quality under contract No. EQ4AC002.



Source: Resource Planning Associates, Inc., and David M. Dornbusch & Co., 1974, "Potential Onshore Effects of Oil and Gas Production on the Atlantic and Gulf of Alaska Outer Continental Shelf," prepared for the Council on Environmental Quality under contract No. EQ4AC002.

Figure 7-13. Northeast Florida/Southeast Georgia Land, Developed and Undeveloped



Source: Resource Planning Associates, Inc., and David M. Dornbusch & Co., 1974, "Potential Onshore Effects of Oil and Gas Production on the Atlantic and Gulf of Alaska Outer Continental Shelf," prepared for the Council on Environmental Quality under contract No. EQ4AC002.

Figure 7-14. Northeast Florida/Southeast Georgia Land Suitable for Primary Development

ment and land use extensively, and degrade the environment. These impacts are at least partially controllable by siting and development policies that encourage environmental protection and good design.

Chapter 7 highlights some of these major impacts. It does not attempt to describe every possible onshore staging point but rather to illustrate a technique for evaluating what will happen onshore if oil and gas are discovered and produced in given areas.

The impacts for high-level Atlantic OCS production are indicated in Table 7-20 and in Table 7-21 for Alaska and the Pacific. The tables show offshore platforms, refineries, gas processing plants, petrochemical complexes, value of construction, employment, population, acreage, hydrocarbon loadings, and BOD levels.

Economic Impacts

Economic impacts, including employment and output, vary from region to region. By the year 2000, as many as 75,000 additional jobs would be created in one sample area (Charleston) and as many as 120,000 in one sample region (South Carolina and Georgia) under high OCS production assumptions. These figures represent 40 and 25 percent increases over expected conditions without offshore drilling in the area and region, respectively.

Not all regions would experience such growth. In New England, less than 20,000 new jobs would be created in the local area (9 percent over the base case) and about 80,000 jobs in the region (3 percent). The west coast growth is somewhat smaller—about 20,000 new local jobs and 40,000 or fewer for each region.

Impacts in Alaska would be smaller in terms of the absolute number of jobs but much more significant in terms of percentage increases. Under low OCS production assumptions, new employment would be roughly one-third to one-half of the high development case.

Of the five industrial sectors analyzed—oil and gas recovery, gas processing, refining, petrochemicals, and construction—construction in 1985 and petrochemicals in 2000 tend to be the largest employers. The assumed

TABLE 7-18

Solano/Contra Costa Counties Aggregate Economic Impacts, High Development

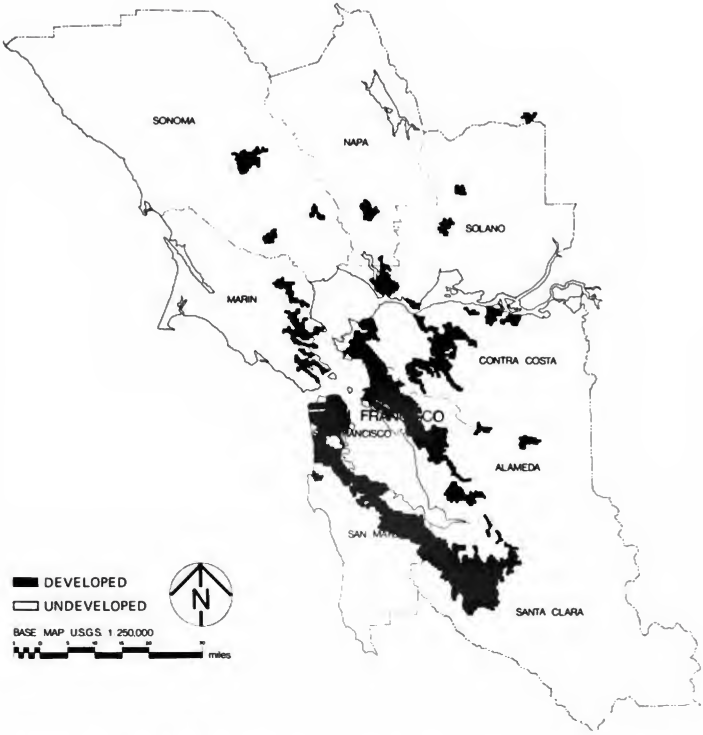
Sector	1985	Percent over BC 1	Percent over BC 2[1]	2000	Percent over BC 1	Percent over BC 2[1]
Employment (thousands)						
Construction	5.9	31	–	1.8	7	–
Refining, gas processing, petrochemicals	1.3	38	–	4.9	176	–
Other manufacturing	2.2	5	–	3.5	6	–
Agriculture	*	*	–	*	*	–
Utilities	0.7	4	–	1.3	6	–
Services	6.3	3	–	10.5	4	–
Total	16.4	6	–	22.0	5	–
Value of output ($ million)[2]						
Construction	194	25	–	78	6	–
Refining, gas processing, petrochemicals	484	29	–	1,716	102	–
Other manufacturing	120	14	–	264	9	–
Agriculture	*	*	–	1	*	–
Utilities	28	4	–	73	6	–
Services	149	3	–	308	4	–
Total	975	11	–	2,440	15	–

* = negligible.

[1] There is no Base Case 2.

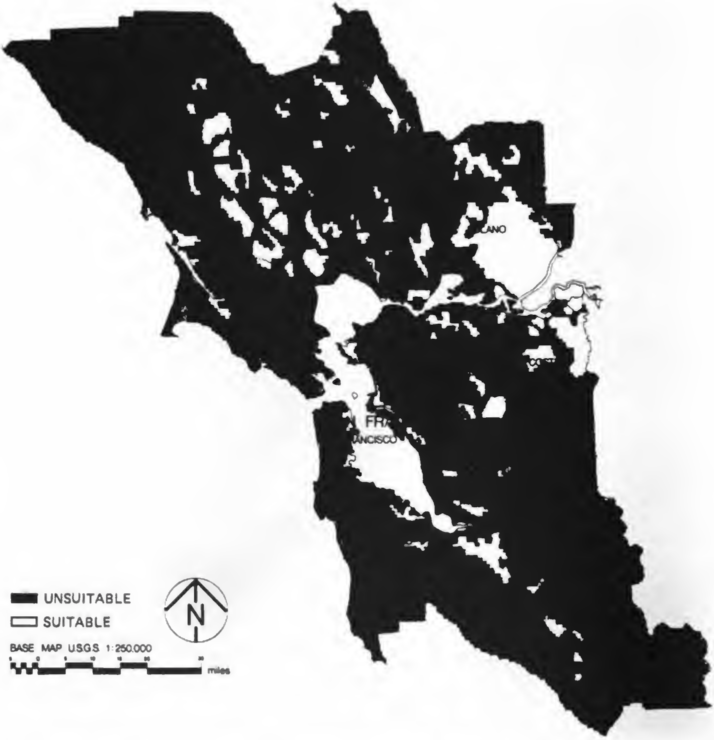
[2] All dollar figures are 1970 constant dollars.

Source: Resource Planning Associates, Inc., and David M. Dornbusch & Co., 1974, "Potential Onshore Effects of Oil and Gas Production on the Atlantic and Gulf of Alaska Outer Continental Shelves," prepared for the Council on Environmental Quality under contract No. EQ4AC002.



Source: Resource Planning Associates, Inc., and David M. Dornbusch & Co., 1974, "Potential Onshore Effects of Oil and Gas Production on the Atlantic and Gulf of Alaska Outer Continental Shelf," prepared for the Council on Environmental Quality under contract No. EQ4AC002.

Figure 7-17. San Francisco Bay Land, Developed and Undeveloped



Source: Resource Planning Associates, Inc., and David M. Dornbusch & Co., 1974, "Potential Onshore Effects of Oil and Gas Production on the Atlantic and Gulf of Alaska Outer Continental Shelf," prepared for the Council on Environmental Quality under contract No. EQ4AC002.

Figure 7-18. San Francisco Bay Land Suitable for Primary Development

TABLE 7-19

Solano/Contra Costa Counties Social Infrastructure Impacts

		1985				2000			
	1970	Base Case 1	Base Case 2[1]	Increase		Base Case 1	Base Case 2[1]	Increase	
				High development	Low development			High development	Low development
Population (thousands)	728	1,077	–	34	18	1,530	–	42	17
Percent change			–	3	2		–	3	1
Physical systems									
Water demand (million gallons per day)	125	183	–	6	3	291	–	8	3
Electricity demand (megawatt capacity)	NA	NA	–	193	59	NA	–	663	228
Structures									
Residential (thousands)	226	334	–	11	6	474	–	13	5
Commercial (million square feet)	16	26.9	–	.9	.5	40.2	–	1.1	.4
Social systems									
Schools – enrollees (thousands)	209	301	–	10	5	428	–	11	4
Hospitals – beds	2,190	3,134	–	99	52	4,452	–	122	49
Police – manpower	1,336	1,936	–	61	32	2,754	–	76	31
Solid waste (tons per day)	2,184	3,231	–	102	54	4,590	–	126	51
Sewage (million gallons per day)	87	129	–	4	2	184	–	5	2
Government overhead ($ million)	NA	139	–	4	2	197	–	5	2
Business and government institutions									
Business services – employees (thousands)	NA	NA	–	NA	NA	NA	–	NA	NA
Government employees (thousands)	25.1	37.3	–	1.2	.6	52.4	–	1.4	.6

[1] There is no Base Case 2.

Source: Resource Planning Associates, Inc., and David M. Dornbusch & Co., 1974, "Potential Onshore Effects of Oil and Gas Production on the Atlantic and Gulf of Alaska Outer Continental Shelves," prepared for the Council on Environmental Quality under contract No. EQ4AC002.

development timetables result in maximum construction employment in the 1980's to support the rapid refining and petrochemical development that occurs as OCS production builds to its 1990's peak. The demand for construction workers in 1985 would lead to shortages of skilled personnel in some areas. Overall, the largest employer will be the service sector that supports these industries and the larger population.

The significant demands for labor could lower local and regional unemployment rates relative to other areas of the Nation. But low unemployment will not always result because publicity often attracts more workers than are needed and unemployment remains high. The increased demand for labor may also raise average wages in an area and therefore the average per capita income of each area. However, income benefits may not always accrue to current residents of the area but may instead go to imported labor.

Specific industrial sectors within each area will be especially affected. Less land will be farmed, for example, due to the demand for large land parcels for industrial development and to increasing land values and taxes. Commercial fishing may be seriously damaged by both water pollution and mechanical interference from increased marine activity. Experience in Alaska indicates that per capita income of fishermen may decrease. Consideration must be given to the fact that fisheries are renewable resources and are continuing sources of income, whereas minerals may be depleted in our lifetime.

TABLE 7-20

Summary of Onshore Impacts, East Coast: High Development[1]

Key impacts	New England				Mid-Atlantic			
	1985		2000		1985		2000	
	Local	Region	Local	Region	Local	Region	Local	Region
Primary impacts								
Number of offshore platforms (25,000 barrels per day)	38	38	68	68	38	38	68	68
Number of refinery equivalents (200,000 barrels per day)	1.4	2.8	2.8	5.6	1.9	4.2	2.8	7.2
Number of gas processing plants (500 million cubic feet per day)	2	2	4	8	2	2	4	8
Number of petrochemical complex equivalents (1 billion pounds per year olefins)	0	0.5	0.8	2.4	1.0	2.2	1.9	6.0
Value of incremental construction (millions of 1970 dollars)	196	387	79	155	118	332	7	84
Aggregate impacts								
Employment (thousands)	19.0 (9)	76.7 (3)	17.3 (7)	83.1 (3)	28.8 (19-30)	100.2 (2)	31.9 (20-29)	120.8 (2)
Population (thousands)	43.6 (9)	188.8 (3)	38.8 (7)	191.7 (3)	59.6 (19-27)	227.0 (2)	66.0 (19-26)	268.6 (2)
Acreage required (thousands)	7.0 (8-9)	24.3 (3)	8.0 (9)	26.9 (3)	32.4 (18-26)	49.3 (4)	35.5 (18-25)	57.0 (4)
Hydrocarbon loadings (thousand tons per year)	16.6 (592)	36.6 (6-8)	34.6 (1116)	71.9 (87-134)	27.3 (41-273)	57.3 (7-14)	40.2 (41-338)	103.6 (11-27)
Biological oxygen demand (million tons per year)	0.9 (14)	3.2 (5)	1.8 (23)	5.7 (6)	1.6 (29-68)	4.3 (4)	2.4 (30-104)	7.8 (6)

See footnotes at end of table.

TABLE 7-20—*Continued*

Summary of Onshore Impacts, East Coast: High Development

Key impacts	South Atlantic/Charleston				South Atlantic/Jacksonville			
	1985		2000		1985		2000	
	Local	Region	Local	Region	Local	Region	Local	Region
Primary impacts								
Number of offshore platforms (25,000 barrels per day)	38	38	68	68	38	38	68	68
Number of refinery equivalents (200,000 barrels per day)	1.4	2.8	2.8	5.6	1.4	1.4	2.8	4.2
Number of gas processing plants (500 million cubic feet per day)	2	2	4	8	2	2	4	8
Number of petrochemical complex equivalents (1 billion pounds per year olefins)	1.2	2.4	4.2	7.4	0	0	4.2	5.8
Value of incremental construction (millions of 1970 dollars)	228	405	91	162	271	434	108	174
Aggregate impacts								
Employment (thousands)	59.2 (29-41)	87.9 (19-24)	75.8 (28-38)	109.9 (20-25)	37.0 (9-10)	53.9 (11-12)	58.7 (12-13)	84.6 (14-16)
Population (thousands)	137.5 (27-34)	250.8 (20-25)	145.4 (24-31)	272.9 (20-25)	82.3 (9)	142.8 (12-13)	111.2 (10)	202.4 (15-16)
Acreage required (thousands)	26.0 (24-29)	64.6 (16-18)	29.6 (23-29)	75.4 (17-20)	25.4 (7-8)	43.2 (9-10)	33.3 (8-9)	64.9 (11-14)
Hydrocarbon loadings (thousand tons per year)	24.5 (75-150)	48.4 (44-111)	47.6 (11-24)	94.9 (62-175)	17.6 (73-149)	21.2 (43-64)	43.2 (111-294)	71.8 (73-156)
Biological oxygen demand (million tons per year)	2.1 (53-78)	5.6 (28-44)	4.3 (81-120)	10.8 (37-60)	2.8 (13-15)	3.8 (15-17)	8.1 (25-31)	11.7 (28-38)

[1] All imports are over base case conditions. The numbers in parentheses represent percentages over base case conditions, the first over Base Case 2 and the second over Base Case 1; where there is only one number, the percentage increase is the same for either base case.

Source: Resource Planning Associates, Inc., and David M. Dornbusch & Co., 1974, "Potential Onshore Effects of Oil and Gas Production on the Atlantic and Gulf of Alaska Outer Continental Shelf," prepared for the Council on Environmental Quality under contract No. EQ4AC002.

TABLE 7-21

Summary of Onshore Impacts, West Coast: High Development[1]

Key impacts	Alaska				Washington/Oregon				Northern California			
	1985		2000		1985		2000		1985		2000	
	Local	Region	Local	Region	Local	Region	Local	Region	Local	Region	Local	Region
Primary impacts												
Number of offshore platforms (25,000 barrels per day)	19	19	60	60	NA	NA	NA	NA	NA	NA	NA	NA
Number of refinery equivalents (200,000 barrels per day)		0		0	0.1	0.1	1.3	1.3	1.3	1.3	3.5	3.5
Number of gas processing plants (500 million cubic feet per day)		2		16	0	0	0	0	0	0	0	0
Number of petrochemical complex equivalents (1 billion pounds per year olefins)		0		0	0	0	3.0	3.0	0.5	0.5	2.9	2.9
Value of incremental construction (millions of 1970 dollars)		55		21	214	214	86	86	194	194	78	78
Aggregate impacts												
Employment (thousands)		4.4 (2)		3.7 (1)	11.0 (17)	17.3 (2)	16.5 (19)	32.2 (2)	16.4 (6)	28.3 (1)	22.0 (5)	42.7 (1)
Population (thousands)		16.0 (4)		12.9 (2)	22.0 (15)	39.0 (2)	31.4 (17)	71.0 (2)	33.7 (3)	67.3 (1)	42.4 (3)	97.0 (1)
Acreage required (thousands)		NA		NA	8.1 (12)	10.8 (2)	13.2 (16)	18.5 (3)	5.2 (3)	7.3 (1)	7.8 (4)	10.9 (2)
Hydrocarbon loadings (thousand tons per year)	NA	NA	NA	NA	1.7 (3)	1.8 (2)	23.4 (42)	23.6 (18)	15.1 (21)	15.5 (11)	43.3 (48)	43.7 (25)
Biological oxygen demand (million tons per year)	NA	NA	NA	NA	0.2 (7)	0.7 (1)	2.2 (53)	3.7 (4)	1.3 (15)	1.8 (2)	3.8 (12)	4.6 (3)

[1] All imports are over base case conditions. The numbers in parentheses represent percentages over base case conditions, the first over Base Case 2 and the second over Base Case 1; where there is only one number, the percentage increase is the same for either base case.

Source: Resource Planning Associates, Inc., and David M. Dornbusch & Co., 1974, "Potential Onshore Effects of Oil and Gas Production on the Atlantic and Gulf of Alaska Outer Continental Shelf," prepared for the Council on Environmental Quality under contract No. EQ4AC002.

The demand for hotels, motels, restaurants, and temporary housing for construction workers could be stimulated. On the other hand, recreational industries could be hurt, especially where the character of the communities is one of isolation, historic preservation, or natural beauty. Resort and recreational patterns could be radically altered by offshore drilling and production. A major oil spill along the beaches of Cape Cod, Long Island, or the Middle or South Atlantic states could devastate the area affected.

Assuming that the goal toward U.S. energy self-sufficiency is vigorously pursued, aggregate domestic oil, gas, and coal production will rise correspondingly. Any employment, investment, income, or population shifts to regions or localities resulting from Atlantic or Alaska oil and gas development will probably represent shifts away from other areas. For OCS development the shift will be to coastal areas, thus reinforcing what some consider an undesirable trend of population movement.

Social Infrastructure Impacts

OCS-related development onshore will create new markets and new demands on land and services to support the industries and employees who locate in an area. Although land use planning and controls can reduce the damage of such development to the environment and to the fiscal capacity of a community, the pace at which development occurs and the tremendous changes that it will bring in some communities make careful analysis of the effects of the development an essential part of any community's decision to allow the refineries and other facilities to come in.

Population increase figures are one measure of the kinds of impacts that can be anticipated. Increases of between 20,000 and 145,000 over base case projections may be expected in sample areas (excluding Alaska). Low OCS development could require one-third to one-half of this growth. Impacts appear greatest in the Charleston area, where the added population could almost double the current population and would be the equivalent of building a new city in little over a decade. Increases in Alaska, though smaller in absolute numbers, would be greater in degree because of the impacts on lifestyles and on pristine, fragile ecosystems. Table 7-22 shows the impacts on employment and population in several Alaskan communities. In all other regions except Florida and Alaska, increases would be less than 5 percent, although local areas in New Jersey, Jacksonville, and Puget Sound could experience significant growth.

The concomitant demand for services—schools, hospitals, transportation, housing, commercial facilities, sewers, office space, and public utilities—may be difficult for some communities to meet. Water demand is approximately 65 percent by the direct industries, 22 percent indirect, and 13 percent for residential and commercial use. Industry's major water use is for cooling, a need that can be satisfied at coastal locations. The sample areas with the greatest water supply prob-

TABLE 7-22

Alaskan Community Impacts

	Valdez	Cordova	Seward	Yakutat
Population				
1970	1,100	1,600	1,800	250
1985 base case	9,600	3,800	3,300	400
1985 low development	11,500	5,700	5,200	2,300
1985 high development	13,800	8,000	7,500	4,600
2000 base case	25,800	5,600	4,800	600
2000 low development	28,100	7,900	7,100	2,900
2000 high development	29,200	9,000	8,200	4,000
Employment				
1970	325	475	800	100
1985 base case	2,830	1,190	1,160	160
1985 low development	3,190	1,550	1,520	520
1985 high development	3,880	2,240	2,210	1,210
2000 base case	7,200	1,740	2,200	260
2000 low development	7,500	2,040	2,500	560
2000 high development	8,040	2,580	3,040	1,100

Source: Resource Planning Associates, Inc.

lems are San Francisco and southern New Jersey, although the Charleston area would have some supply problems. Planning for these public services and facilities would require large increases in local government overhead. Furthermore, the service infrastructure and the needed new housing and commercial facilities would require major capital expenditures; in the Charleston area alone, needed mortgage financing is estimated at about $1 billion.

In all areas infrastructure impacts could strain individual communities. The ability of a given community to cope with this growth depends largely on its size, its existing capacity to plan and control growth, and its financial structure. A city like Jacksonville, where rapid growth has already occurred and planning agencies exist, should be able to respond to OCS-related growth if it desires. But small areas and those without much experience handling growth may be unable to meet demands.

There may also be great changes in the social and psychological fabric of communities. The transition from rural life to an industrial economy involves many social, institutional, economic, and psychic changes. Many communities may resist the promise of economic gains in order to preserve their traditional lifestyles and the character of their towns and villages.

The case studies point out a number of these important community impact issues. The New England case study shows how development, if not controlled regionally, will gravitate to a number of smaller towns where residential and commercial activity could threaten the architectural and historic resources that have been protected for generations. Development might better be directed to the declining areas of the larger cities, where the infusion of economic activity is needed. The New Jersey analysis shows greatly reduced community impacts by expanding existing sites and locating new facilities in the already industrialized Delaware Valley. The Charleston case study points out the need for locales to anticipate and plan for large population influxes and to protect their most valuable natural and manmade resources from destruction by the new economic forces at work. Good planning and regulatory programs can channel those forces into desirable development that will enhance the environmental quality and life in an area.

Land Supply

Even under the high development cases, each sample region has sufficient undeveloped land to meet the requirements for OCS-induced development if environmental and locational values were ignored. As much as 75,000 acres of previously undeveloped land would be required in the South Carolina/Georgia region. However, large amounts of undeveloped acreage are really unavailable due to environmental values (e.g., wetlands, ecological sanctuaries, national parks and seashores, and coastal recreation areas), locational constraints (e.g., excessive slopes, inadequate water, and distance from major population centers), and such factors as local preference for agricultural preservation and low-density single-family housing.

Excluding land for these reasons causes a shortage for OCS-related development in some regions. It may be extremely difficult, for example, to find enough land in the San Francisco Bay and Puget Sound regions for base case and OCS-induced growth. In fact, environmental and locational constraints remove about 90 percent of the undeveloped land in the San Francisco Bay region. Land in some of the potential Alaska staging areas is scarce due to land configuration, native claims, and location of natural areas.

It must be emphasized that primary industry need not develop adjacent to offshore production areas. Onshore development sites may be determined more by what land is available when needed than by location alone. If a company has refining capacity in particular locations, it may elect to expand capacity, but if it has no refineries in reasonable proximity or desires to establish capacity in a new area, new sites may be needed.

Although land appears available in most regions, inland locations are often preferable to the environmentally fragile coastal areas. Transporting crude oil inland may not cost as much as the benefits.

Wildlife and Vegetation

The habitat most in danger from OCS-related development is the estuarine wetlands. It can be a land fill site, a source for dredge and fill operations, a solid waste disposal site, agricultural land, and once dried, a site for industrial or residential development. Over time these uses have resulted in loss of a significant percentage of U.S. wetlands, and most states have not taken steps to protect further encroachment. Inland forest, woodland, and wetland habitat can also be harmed by poorly regulated development. Population increases create demands for more highways, houses, shopping centers, etc., which in turn increase the vulnerability of natural areas and other wildlife habitat.

In a relatively undeveloped area like Cumberland and Cape May Counties, N.J., the population growth and related industrial development could adversely affect one of the Nation's most productive and ideally located coastal wetland areas and its productive estuarine zone. With good planning and effective protective measures, however, there is an opportunity to accommodate most development anticipated by OCS activities, especially if upriver sites are used as often as possible. In contrast, in Solano/Contra Costa Counties, Calif., an area that is already relatively developed, even the small population increase and related development expected with OCS production could significantly increase the pressures on the limited remaining wildlife habitat.

In all the localities and regions the impact will be determined by the way that development is handled. Design and siting decisions and good wildlife management practices can help prevent or mitigate damage. In the case of OCS-related development, this may mean narrow pipeline or tanker corridors, restoration of any disturbed areas, and inland siting.

Air and Water Pollution Impacts

Air and water pollution are not generally expected to be significant with use of emission and effluent control technologies. In selected locations, hydrocarbon emissions and BOD levels may rise due to concentration of refineries and petrochemical industries. In these areas, decreased hydrocarbon emissions as a result of auto emission controls would be offset by new sources of hydrocarbons. Where significant increases in population are anticipated, as in Charleston, auto emissions may also be a factor.

Before any definitive conclusion can be reached about air and water quality levels in a particular area, diffusion modeling is necessary. Ambient levels do not always relate directly to emissions, and health standards could be exceeded, depending upon exact location, terrain, and meteorological conditions. Other pollutants, such as hydrogen sulfide, oils and grease, phenols, and ammonia should be carefully controlled.

Gas recovery and processing have significantly less environmental, economic, and social impacts than oil recovery and processing more so when petrochemical complexes are associated with crude oil refining. For example, a typical refinery of 200,000 barrels per day employs 500 people, contributes $330 million to economic output, and requires 1,200 acres of land. A typical gas processing plant of 500 million cubic feet per day employes 50 people, contributes $11.8 million to output, and requires about 20 acres of land.* Oil-induced development is considerably more vast than gas-induced development and also produces more pollution emissions.

Barring major changes in the U.S. import policy in the next few years, refinery and petrochemical industry growth may be expected prior to OCS development in conjunction with possible dispersed deepwater terminals to receive oil imports. The impacts of this growth should be similar in each local area and region to the onshore impacts of high OCS development. How the areas respond to import-induced growth should set the stage for understanding possible response to OCS-induced development. The planning process and mechanisms for resolving conflicting interests are discussed further in Chapter 9.

REFERENCES

1. Resource Planning Associates, Inc., and David M. Dornbusch & Co., 1974, "Potential Onshore Effects of Oil and Gas Production on the Atlantic and Gulf of Alaska Outer Continental Shelves," prepared for the Council on Environmental Quality under contract No. EQ4AC002.
2. Arthur D. Little, Inc., 1973, *Potential Onshore Effects of Deepwater Oil Terminal-Related Industrial Development*, prepared for the Council on Environmental Quality under contract No. EQC220 (NTIS Accession Nos. PB-224 018, Vol. I; PB-224 019, Vol. II; PB-224 020, Vol. III; PB-224 021, Vol. IV; PB-224 017, set).
3. Resource Planning Associates, Inc., supra note 1.
4. University of Oklahoma Technology Assessment Team, *North Sea Oil and Gas*, prepared for the Council on Environmental Quality under contract No. EQC328 (Norman: University of Oklahoma Press, 1973), p. 102.
5. Radian Corporation, 1974, *A Program to Investigate Various Factors in Refinery Siting*, prepared for the Council on Environmental Quality and the Environmental Protection Agency.

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*The typical refinery used in this report has a capacity of 200,000 barrels per day and produces 1.2 trillion Btu's per day, about twice the BTU production of the typical gas processing plant. The typical gas processing plant here has a capacity of 500 million cubic feet per day and produces 0.5 trillion Btu's per day.

Chapter 8. Technology and Environmental Protection

Technologies for locating and exploiting oil and gas resources in the Atlantic and Gulf of Alaska OCS must be adequate, and they must be used safely to minimize risks to every critical element of the environment. Because oil and gas exploration and production have not occurred in these two OCS areas, technological adequacy must therefore be assessed indirectly. It must be judged on the basis of extensive experience in the Gulf of Mexico and more limited experience off California, in Alaska's Cook Inlet, in the North Sea, and in other offshore operations around the world.

The Atlantic and Gulf of Alaska OCS are hostile environments for oil and gas operations. Storm and seismic conditions may be more severe in these areas than in either the North Sea or the Gulf of Mexico. [1] These natural hazards must, of course, be considered in designing facilities and equipment for the new areas. Further, because they are virgin regions in which the effects of pollution and construction-related activities have not been established, the capability of environmental control technologies to minimize accidental or chronic releases must also be evaluated.

STUDY DESIGN

Performance of offshore oil and gas technologies has been studied extensively since the Santa Barbara blowout in 1969. [2] The reports provide valuable insights and a rational basis for improving Federal regulation and enforcement of OCS operations as well as for improving industrial design and practices. Several of the studies were completed quite recently and therefore are a good measure of the current status of the technology.

Because these recent studies were available and had been subjected to extensive public review and comment, the Council did not conduct a new comprehensive technology assessment. Instead, the Council used the available reports as source documents for this study.

Review of Assessments

Each study presented conclusions on the adequacy of OCS technology and recommendations for improving the technology, its management, and regulation. Many of the recommendations have been or are being considered by the responsible regulatory agencies and by industry. There are differences among the several reports as reflected in conflicting conclusions and recommendations.

Industry representatives objected to incorporation of some recommendations into Federal regulations or industry practices. For example, industry representatives articulated many of their objections at a public briefing on the University of Oklahoma's study, *Energy Under the Oceans*, in Washington, D.C., Sept. 6, 1973, and at the Resources for the Future seminar on Dec. 5-6, 1973, also in Washington, D.C. In some instances, the industry believes, recommendations reflect misunderstandings of complicated oil and gas technologies. Other objections are rooted in different perceptions of how the public interest is best served and in general resistance to further Federal regulation.

To assist in understanding and resolving major technology-related issues, the Council contracted with Resources for the Future, Inc., to organize a seminar at which representatives of industry, Federal agencies, academic institutions, and environmental groups reviewed the earlier technology studies and discussed papers prepared for the seminar. The results of the seminar, summarized by RFF, are discussed in this chapter. [3]

Special Studies

Because OCS operations in the Atlantic and Gulf of Alaska have not been studied previously, the Council contracted for several studies of technological questions which might arise from operations in the new areas. Tetra Tech, Inc., analyzed the possible effects of natural phenomena—severe storms, currents, ice, earthquakes, and tsunamis—on OCS operations in the Atlantic and Gulf of Alaska. [4] The Science and Public Policy Programs of the University of Oklahoma assessed implications of North Sea oil and gas operations for future development on the U.S. OCS. [5] These studies are discussed in this chapter; natural phenomena are also discussed in Chapter 5.

FACTORS INFLUENCING OCS TECHNOLOGIES

Human Factors

One general area that has received considerable attention is the role of human factors engineering in the design of OCS equipment. A common thread in the recommendations of the National Aeronautics and Space Administration, [6] National Academy of Engineering, [7] and University of Oklahoma [8] studies is the need to incorporate elements of human behavioral patterns into OCS technology design, with emphasis on the evolution of damage-limiting and fail-safe systems and techniques. The NASA report recommended use of hazard analysis in which a "design review" group would work with operators to eliminate or reduce hazardous operations and develop new inspection criteria. The NAE panel recommended expanded Government involvement in encouraging and sponsoring development and testing in damage control, fire fighting, and well control. The University of Oklahoma recommended wider use of the systems approach and human factors criteria in OCS technology design, focusing on increased redundancy and fail-safe designs to minimize accidents due to human error.

The man-machine interaction is the critical factor in minimizing the threat of accidents. But it is imperfectly understood and is considered only partially in design.* The RFF seminar concluded that "technology management could be profitably further developed," including improvements in "human factors and man-machine engineering." [10] The continuing search for better technology must build upon an improved understanding of the role of human factors in equipment design and must be coupled with thorough training of the equipment operators. Indeed, "improvements in training and human factors is probably at least as important, if not more, than improvements in technology." [11] The Council recommends that human factors engineering be employed to the fullest extent in the design of OCS oil and gas equipment. The Department of the Interior should review proposed designs for facilities to be used in new OCS areas and encourage the incorporation of man-machine engineering principles.

Personnel Training

The role of personnel training in reducing risks in OCS operations has also received considerable critical review. The NASA, NAE, and Oklahoma reports all recommend significantly expanded industry training programs and Federal Government involvement in guaranteeing the adequacy of these programs. All three recommend Federal standards for personnel training. Both the NASA and Oklahoma studies recommend that nongovernment personnel who inspect and test safety and environmental control equipment be certified to uniform Federal standards. [12]

In part, the industry and the U.S. Geological Survey have recognized the advantages of these recommendations. The American Petroleum Institute (API) has formed a Committee on Offshore Safety and Anti-Pollution Training and Motivation, with Geological Survey participation. Its objective is to identify needed training programs for offshore operating personnel and to compile a checklist of essential training requirements. [13]

In the past few years, the University of South Louisiana at Lafayette and Louisiana State University at Baton Rouge have established well control training schools. The university and in-house industry programs emphasize blowout prevention or control. Drilling accident conditions are being simulated with typical

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*In the 1970 Shell fire in the Gulf of Mexico, a workman failed to close a manual valve before leaving the wellhead. The valve had no open/close indicator; the only way to be certain that the valve was closed was to count the turns. In the 1967 Continental accident, a workman turned the wrong handle in an attempt to actuate the safety system. The emergency valves were similar to production valves and were adjacent to them. Both were unmarked, and under pressure of events, the workman actuated the wrong valve. [9]

OCS hardware on an abandoned pressurized well and with training equipment coupled to a small computer programmed to reproduce any drilling condition that may be confronted.

Although some OCS operators indicate that all personnel, including their contractors, have attended training schools, the industry pattern is quite irregular. Most training schools are relatively new. Their quality has not been evaluated and no system of accreditation has yet been established. Industry initiatives, as described above, are responsive to the need for personnel improvement in order to handle more satisfactorily both routine and accident conditions. However, the API recommendations are advisory only.

Industry representatives believe that potential economic losses from accidents due to inadequate training are sufficient incentive to provide the necessary training. The basic objection to Federal standards setting, accreditation, and certification appears a general reluctance to accede to any further Government involvement in industry activities.*

However, because industry attributes most accidents to human error—rather than to equipment failure—it appears essential that OCS personnel training be broadened, that the quality of training programs meet minimum Federal standards, and that personnel completing the programs be certified. Training programs may not be required for all types of jobs but certainly for the most critical, curriculum standardization and personnel certification should be required. The Council recommends that the Department of the Interior establish minimum Federal standards for critical OCS operator personnel and certify or provide for appropriate accreditation of the training programs.

ASSESSMENT OF OCS OIL AND GAS TECHNOLOGIES

Geophysical Exploration

Passive reconnaissance survey technologies do not cause direct environmental impacts. There were some problems in the past when the sound waves required for seismic surveys were generated with explosives. Propane-oxygen guns or high-powered oscillators now in use appear to have no significant adverse environmental impacts. [15] Both reconnaissance and seismic surveys may conflict with fishing fleets and general navigation unless there is adequate planning.

Bottom sampling and coring have physical impacts on the environment, but these impacts are small and are confined to a very localized area. The threat of oil or gas releases during coring can be minimized by carefully avoiding penetration into consolidated formations in which oil and gas could be trapped. Coring is closely supervised, with U.S. Geological Survey personnel required aboard during such operations. Bottom sampling requires a USGS representative or an approved qualified person aboard.

Exploratory Drilling

Downhole Pressure Measurement. As described in Chapter 4, several safeguards are used to prevent or minimize the effects of blowouts during drilling operations. An integral part of drilling is the use of drilling mud to prevent blowouts by counterbalancing formation pressures and preventing oil or gas flow as the drill bit penetrates the formation. The drilling mud is pumped down the drill pipe (or string) into the hole, out through the drill bit, and back to the surface through the annular space between the drill string and drill hole or casing. It removes the cuttings from the face of the bit and carries them to the platform for disposal. Because of the considerable variation in formation pressure, the force exerted by the drilling mud on the formation must be varied by changing the composition of the mud and the pumping rate.

Because of the importance of detecting sudden changes in formation pressure, several specific technological improvements have been recommended. The Oklahoma team recommended development and general use of downhole instrumentation to measure pressure at the face of the bit and of a more sensitive monitoring system to measure sudden losses or gains of drilling mud. [16]

These recommendations were discussed at length at the RFF seminar, but a consensus for action did not emerge, partly because of differences of opinion on the value of downhole pressure measurements and partly because the current status of the technology was not fully known by all panel members. [17] An industry representative stated: "We certainly agree that the industry has need for drilling instrumentation to monitor downhole pressure at the bit." [18] The RFF seminar panel concluded that this area was "worthy of greater exploration." [19]

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*O.E. Bell, Mobil Oil Corporation, states: "Certification would introduce a licensing concept which customarily requires a statutory basis. Consequently, operators and the employees involved may justifiably have the feeling that certification as proposed would discriminate against them, perhaps unlawfully." [14] There does appear, however, to be adequate legal authority to license or certify at least some OCS operator personnel.

Rapid, accurate measurement of downhole pressure appears important in improving the ability to maintain well control and to reduce the possibility of blowouts. The Council recommends that the Department of the Interior determine which technologies could improve the measurement of the formation pressure near the drill bit and incorporate these into the OCS orders.

Casing and Blowout Preventers. Other ways to prevent blowouts are the setting of casing–large-diameter pipe cemented into the formation to line the drill hole–and installing blowout preventers (BOP) around the drill pipe. BOP stacks are a series of control valves to close off the annular space around the drill pipe or to close off the well completely.

Regulations for installation and use of well casing and BOP equipment in the Gulf of Mexico OCS are covered in OCS Order No. 2. [20] Assuming that regulations and practice in the Atlantic and Gulf of Alaska OCS are no less stringent, it appears that there are no major inadequacies in these two technologies. However, because the specific requirements for both technologies depend upon the characteristics of the formations to be drilled, orders for new OCS areas must be based upon a careful review of the geologic conditions to ensure that the technologies can be transferred. Special precaution should be exercised in the Gulf of Alaska where active seismic zones are common.

Structural Integrity of Drilling Platforms. The integrity of the drilling platform is critical to safe drilling operations. The severe environmental conditions in the Atlantic and Gulf of Alaska OCS–storms, earthquakes, and tsunamis–present an exceptional challenge to platform design. Natural phenomena may cause an OCS structure to collapse, capsize, or be blown off the drilling location, in all cases resulting in the failure of the conductor pipe or riser. If the BOP stack is installed on the ocean floor, failure of the riser would close the well. If it is mounted on the platform as on jackup rigs, then failure of the conductor pipe would open the well and release the drilling mud. If the drill had penetrated an oil- or gas-containing formation, failure of the riser could allow uncontrolled release of oil or gas.

Severe storms present hazards for floating and fixed drilling platforms in the Atlantic and Gulf of Alaska OCS. In these two areas, Tetra Tech reports, the threat may be more severe than in the Gulf of Mexico or even in the North Sea. [21] Despite industry's assurance that the great cost of these platforms requires that they be designed for the most extreme environmental conditions and that they be operated only under design conditions, drilling platforms have been lost in the North Sea, some quite recently.* Scaling-up OCS technology used in less hostile environments to meet the challenges of more hostile conditions has not proved entirely successful during the initial phases of exploratory drilling in new areas. Undoubtedly, the learning curve is very steep, considering platform cost, but the threat to personnel safety and the potential for pollution from loss of well control make it imperative that environmental hazards be fully considered in approving designs for use in the Atlantic and Gulf of Alaska OCS areas.

Although there is usually advance warning of severe storms–from 1 hour in the Gulf of Alaska to 24 hours in the Atlantic–there is no warning for earthquakes and local tsunamis. [24] The threat of such phenomena in the Atlantic is quite small but certainly is not zero. In the Gulf of Alaska seismic events are frequent. Fortunately, a drilling platform that floats should be little affected by earthquakes and tsunamis. Fixed platforms, on the other hand, would be subjected to the full effects of the seismic forces, and their use in the Gulf of Alaska OCS should be carefully weighed. [25] At a minimum, design and construction requirements for such platforms should be rigorously developed.

Risk of oil spills due to natural phenomena during the drilling phase is slight. However, if natural hazards are a significant threat in production and transportation phases, then serious consideration must be given to postponing leasing in an OCS region where oil cannot be safely produced and safely transported to markets.

The Council recommends that the Departments of

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*A compilation of accidents involving exploratory drilling rigs up to 1971 is given in *North Sea Oil and Gas.* That there were no drilling accidents between 1971 and November 1973 (publication date of *North Sea Oil and Gas*) "seems to indicate that industry has been able adequately to meet the challenging drilling conditions encountered in the North Sea." [22] However, in December 1973, Kerr-McGee lost a jackup rig off the Orkneys (about 58 degrees North). Use of a jackup rig that far north is inconsistent with a North Sea rule of thumb: "Jackups, for example, are now used only in the southern portion of the North Sea, south of 56 degrees, where water depths are less than 300 feet and the weather is less severe than north of that latitude." [23]

the Interior and Transportation coordinate their evaluation and approval procedures for drilling platforms in new OCS areas. They should prepare detailed performance requirements for such platforms, considering fully the potential natural hazards in these areas.

Drilling Waste Disposal. The current practice in the Gulf of Mexico is to dispose of drill cuttings, sand, drilling mud, etc., in the Gulf. OCS Order No. 7 requires that oil be removed from drill cuttings, sand, and other solids before disposal and proscribes the dumping of drilling mud containing oil in the ocean. Further, drilling mud containing toxic substances must be neutralized and other harmful substances treated before disposal. [26]

Because little is known about how these drilling-associated materials affect marine organisms, the Bureau of Land Management is now implementing a research program to determine the effects. [27] If it is demonstrated that these substances significantly harm marine biota, offshore operators should be required to use advanced treatment or onshore disposal.

The Council recommends that the Department of the Interior, in coordination with the Environmental Protection Agency, develop more detailed guidelines for the disposal of drilling muds, drill cuttings, and other materials, considering fully the results of the BLM monitoring studies of ocean disposal of these materials in new OCS areas.

Field Development

Structural Integrity of Fixed Production Platforms. As discussed in connection with fixed drilling platforms, the hostile Atlantic and Gulf of Alaska environments raise questions about the structural integrity of fixed production platforms. Because of the more severe storm conditions, bigger and stronger fixed production platforms are being installed in the North Sea than are used in the Gulf of Mexico.* However, "some analysts believe that the use of steel platforms, largely an American technology which has evolved in shallower waters, may be stretched to its limit in the North Sea." [29] Concrete platforms and subsea production systems may have to be used instead of steel platforms under some environmental conditions in the Atlantic and Gulf of Alaska OCS.

Earthquakes in the Gulf of Alaska present a significant threat to fixed production platforms. Although fixed platforms in Cook Inlet withstood a nearby earthquake of Richter magnitude 6.5 without damage, platforms have not been designed to withstand the potential earthquake forces of the Gulf of Alaska OCS. Tetra Tech reports that in the vicinity of possible operations in the Gulf of Alaska OCS, there have been eight earthquakes within the past 60 years having magnitudes greater than 7.0 Richter, including the major earthquake of 1964 which measured in the range of 8.3 to 8.6 on the Richter scale. [30]

One production platform—a 940-foot steel platform proposed for the Santa Ynez Unit of the Santa Barbara Channel—has been designed (but not yet constructed) to withstand a nearby moderate earthquake (Richter magnitude 6.5 to 7.5) without damage and to survive a great earthquake (Richter magnitude greater than 8) on the San Andreas Fault without collapsing but with some permanent deformation. [31]

Industry believes that "existing platform design and installation procedures, including consideration of oceanographic and earthquake conditions, will be satisfactory" for use in the Gulf of Alaska and Atlantic OCS. [32] The RFF seminar panel agreed that: "Technological solutions exist for transfer to the new areas. These solutions are generally based on present practice and do not include significant needs for developing new technology." [33]

In OCS Order No. 8 for the Gulf of Mexico, which covers platform approval procedures, the offshore operator has only to prove that "the platform has been certified by a registered professional engineer." [34] This regulatory approach is inadequate with considerably harsher environmental conditions, particularly in the Gulf of Alaska. To see if the industry's optimism is warranted, it is essential that an independent analysis of the risks be undertaken. The integrity of fixed platforms subjected to earthquake forces has been analyzed only by industry and has not included consideration of the possible seismic events expected in the Gulf of Alaska OCS.

The Council recommends that the Department of the Interior develop and incorporate in OCS Orders detailed performance requirements for production platforms and associated equipment to be used in new OCS areas, with full consideration of potential natural hazards. The department should strengthen in-house capability or should contract with a qualified independent firm to evaluate the adequacy of the proposed designs to guarantee structural integrity subject to natural and manmade forces.

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*"Two of the largest platforms ever built are scheduled to be installed in 1975 in 400 feet of water in British Petroleum's Forties field. Each of these platforms will weigh about 48,000 tons, have bases measuring 200 by 250 feet, and have three decks, each 120 by 135 feet. There will be 100 feet of clearance between the deck section and the mean water surface. Design criteria include protection against winds of 130 miles per hour and waves of 94 feet. In comparison, a large, equipped platform in 300 to 400 feet of water in the Gulf of Mexico weighs around 12,000 tons, has a 130 by 210 foot base, two 80 by 160 foot decks, and a clearance of about 50 feet between the deck and the water. Design criteria include protection against winds of 160 miles per hour and 75 foot waves." [28]

New Technologies for Production Facilities. Progress has been made toward development of safe, economically attractive subsea systems, as described in Chapter 4. Advantages of subsea systems include fail-safe and redundancy characteristics which improve reliability and safety, increased automation which can reduce the likelihood of human-error accidents, reduced threats of storm damage, and reduced conflict with surface uses of the ocean. [35]

Industry believes that economics, rather than the possibility of safer, more reliable production, will dictate whether or when subsea systems are used. It appears that many factors–earthquake and storm protection, interference with shipping and fishing, etc.–will enter into the economics of the Atlantic and Alaska OCS operations.

Some industry representatives state that fishing would be hurt more by subsea systems than by fixed platforms. This might occur if many individual wellheads were spread over the ocean floor rather than clustered as they are with Exxon's system, which uses directional drilling (see Figure 4-7). In addition, it is conceivable that with the aid of a shield or dome, subsea wellheads could avoid snagging fishing nets.

The Council recommends that subsea production equipment be used in new OCS areas where it would provide a higher degree of environmental protection and reduce conflict between oil and gas operations and competing uses of the ocean–navigation, fishing, etc.

Subsurface Safety Valves. Until June 5, 1972, the Geological Survey required that each OCS well have a downhole valve that would be actuated by changes in the velocity of the production stream. In other words, when well control was lost and a blowout began, the increased flow would close the valve. Reliability of the valves was not high, in part because sand carried by the oil eroded the valves. In Shell's Bay Marchand fire in 1970, 10 of 42 velocity-actuated subsurface valves failed to close; in Amoco's 1971 fire, 4 of 10 failed. [36]

After the Shell and Amoco fires, USGS required the installation of remotely actuated subsurface valves in most new wells and in existing wells as the tubing is removed and reinstalled.

> The hydraulically operated surface-controlled subsurface safety valve provides improved protection under many operating conditions.... They are fail-safe as positive hydraulic pressure must be maintained to hold them in an open position. Being controlled from the surface, hydraulically operated valves may be tested as frequently as necessary to insure proper operation. [37]

An important feature of revised OCS Order No. 5 is the recognition of probable future technological improvements in subsurface safety valves: such improved designs "may be required or used upon application, justification, and approval." [38] The order should certainly apply to the Atlantic and Alaska OCS areas.

Industry efforts to improve offshore equipment and practices including, of course, subsurface safety valves, were expanded in 1972 by the establishment of API Committees on Offshore Safety and Anti-Pollution Research and on Offshore Safety and Anti-Pollution Standardization. A research project has been funded at the University of Tulsa to improve design and procedures for velocity-controlled subsurface safety valves. Texas A&M University will determine the current status of sand erosion detection and will research erosion mechanics and detection equipment. The Standardization Committee has concentrated on standards, operating practices, quality assurance, and surface safety valves and has completed both a specification and recommended practice for subsurface safety valves. [39]

The Council recommends that the Department of the Interior develop detailed performance requirements of surface-actuated subsurface safety valves and require their use on all production wells in new OCS areas where technically feasible. The department should encourage the development of such valves with higher pressure ratings and with improved reliability of operation over the life of the devices.

Pollution Abatement. Pollution control standards for OCS oil and gas operations are now covered by OCS Order No. 7. [40] The USGS standard of 50 parts per million for average oil content in waste water discharge was criticized in the RFF seminar for being "completely arbitrary, having been set with an eye towards OCS equipment capability rather than towards a desirable environmental standard." [41]

If the FWPCA Amendments of 1972 apply to OCS operations, the Environmental Protection Agency may set technology standards for waste water and other discharges from such facilities (see Chapter 9).

As Chapter 4 points out, chronic oil pollution from offshore operations remains a problem that

> has not generated widespread public concern or reaction. Furthermore, it is clear... that the long-term effects of this type of pollution are not well understood. It is equally clear that it is well within the state-of-the-art to reduce existing chronic pollution by improvements both in technology and in routine housekeeping procedures. [42]

The RFF seminar concluded that "there are other techniques for improved treatment that may be appropriate." [43]

In undeveloped areas like the Atlantic and Gulf of Alaska OCS, environmental loadings of oil and other materials should be kept at the lowest levels possible at least until baseline studies such as those recently initiated by the Bureau of Land Management determine the environmental risk from such materials. [44]

The Council recommends that the Department of the Interior and the Environmental Protection Agency, in cooperation, establish effluent standards for waste water discharge from OCS drilling, production, and associated operations. Strong consideration should be given to requiring installation of the best available control technology for oil-water separation in new OCS areas.

Workover and Servicing. Workover and servicing can be hazardous because well control may be lost and because contractor personnel may be unfamiliar with a company's equipment or procedures.* Development of procedures with common elements would allow adequate flexibility for individual companies while providing greater security. Further, available equipment allows the downhole servicing tools to be inserted in a separate parallel circuit while the well is closed. Using such equipment should considerably reduce the threat of a blowout during servicing. Only a few wells now have this equipment.

The Council recommends that the Department of the Interior develop detailed performance requirements of safety practices for workover and servicing operations on production platforms and incorporate these in OCS orders for the new areas. The department should revise regulations encouraging the use of improved technology to minimize the threat of blowouts during these operations.

Oil and Gas Transportation and Storage

Most OCS oil and all OCS gas are now transported to shore by pipeline. Transportation by tanker and temporary storage offshore may be more common if new OCS areas far from shore are developed.

Pipeline Transportation. Pipelines have been characterized as the safest mode of oil transport and the largest single source of chronic oil pollution offshore. Both of these claims may be correct. Industry points to the fewer human fatalities resulting from pipelines relative to other transportation modes. "The frequency of pipeline fatalities is 30 times less than marine, 250 times less than rail, and 1,000 times less than highway trucking" per ton-mile of oil transported. [46] In addition, industry claims that pipelines cause little environmental damage because there are few accidents and they release little oil. The available data, however, are subject to several interpretations.

Four of the 43 major OCS accidents were associated with pipeline transportation of oil. Two breaks were caused by anchor dragging—the pipelines were not adequately buried. One was the largest ever resulting from OCS operations; it released 160,000 barrels and was not detected for 10 days. The other break released 6,000 barrels. The third pipeline accident was caused by overpressurization and released 900 barrels of oil into the Santa Barbara Channel in 1969. The cause of the fourth, which released over 7,000 barrels of oil, was not determined.

On the basis of U.S. Coast Guard data, the Oklahoma team suggested that pipelines appear to be "a major source of chronic pollution." [47] In 1971 (the only complete year available at that time), 1,267 "line leaks" and 376 "pipe ruptures or leaks" released 13,300 barrels of oil into U.S. coastal waters, "84 percent of all oil introduced into U.S. coastal waters by offshore facilities."

M.I.T.'s analysis of the 1971 Coast Guard data essentially confirms this finding. [48] Using 1972 Coast Guard data, M.I.T. found that of 2,252 total offshore oil spills, only 41 were attributed to pipelines—that is, only 2 percent of the spills and 3 percent of the volume. In 1971, 56 percent of the spills and 82 percent of the spill volume were attributed to pipelines. This large discrepancy is impossible to explain but may be due in part to whether personnel preparing the data assigned the spills to the offshore production category or the offshore pipeline category. Many of the pipeline spills occur on or near production platforms, so such a confusion may be understandable. From this example one can see the inherent limitations in basing recommendations for needed improvements on the Coast Guard data.

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*Responsibility for pollution abatement when contract personnel are involved is not clear. OCS Order No. 7 states only that "[n]on-operator personnel shall be informed in writing, prior to executing contracts, of the operator's obligations to prevent pollution." [45]

The EPA Petroleum Systems Reliability Analysis Study* found that of 8,473 onshore and offshore oil spills, 4,423 spills (or 52 percent) were due to gathering and distribution systems, primarily pipelines. [50] However, of 1,019 oil spills offshore, only 56 (or 5.5 percent) resulted from the gathering and distribution systems, and 44 of the 56 were associated with pipelines. On the basis of these data, pipelines are considerably less of a hazard than production systems (which accounted for 935 spills or 92 percent of the total offshore spills). Again one must bear in mind how accidents associated with pipelines on or near platforms may be categorized.

The Council recommends that the Departments of the Interior and Transportation and the Environmental Protection Agency develop and implement a common reporting system for all accidents associated with OCS operations. This improved system should provide complete, unambiguous reporting, with special attention to the analysis of cause–effect relationships.

Corrosion. Few offshore pipe incidents have been reported; this is due to the relatively young age of offshore facilities and to strong corrosion prevention measures taken by offshore operators. These measures are especially important because corrosion appears to be the major cause of pipeline failures. It attacks pipelines both externally (80 percent) and internally (20 percent). [51]

External corrosion results from action of seawater and soil generally over many years. Office of Pipeline Safety (OPS) data indicate that of 309 onshore petroleum pipeline failures (releasing more than 50 barrels of oil per failure), 73 were due to external corrosion. [52] Thirty-nine had been installed before 1930 and 66 before 1950.

In contrast, chemicals in oil--hydrogen sulfide, dissolved oxygen, salt water, fatty acids, etc.–may act relatively quickly to cause internal corrosion. Twenty-five pipeline failures due to internal corrosion were reported in the 1972 OPS data; 15 had been installed in the 1960's and 7 in the 1950's.

Mitigation of external corrosion involves use of coatings to separate the pipe physically and/or electrically from the corrosive media; substitution of less corrosive materials such as plastic, aluminum, and stainless steel; and cathodic protection, an electrical method of preventing corrosion. OCS Order No. 9 requires that "[a]ll pipelines shall be protected from loss of metal by corrosion that would endanger the strength and safety of the lines either by providing extra metal for corrosion allowance, or by some means of preventing loss of metal such as protective coatings or cathodic protection." [53]

Internal corrosion can be mitigated by coating the inside of the pipe or by injecting corrosion inhibitors, chemical substances, or bactericides into the pipe. Coatings protect the metallic surface from chemical attack. Inhibitors form a thin passive chemical film on the surface. Chemical treatment includes the use of oxygen scavengers to reduce the dissolved oxygen concentrations, dehydrators to remove water, and alkalines to reduce the acidity in the fluid(s) being pumped. Bactericides eliminate bacteria that accelerate corrosive processes.

The Oklahoma team pointed out the need for methods to detect weak points and flaws in long pipelines. At present there is no satisfactory technique available.

The Council recommends that the Departments of the Interior and Transportation develop detailed performance requirements for OCS pipeline protection and undertake the development of pipeline integrity monitors to detect incipient failures in OCS pipelines.

Pipelaying. Development in parts of the Atlantic and Gulf of Alaska OCS would require laying pipelines at depths beyond current technology. An industry appraisal of the status of deepwater pipelaying technology states:

> The offshore pipeline construction industry presently has a demonstrated ability to lay 32-inch diameter pipe in 420-foot water depths. This pipe was laid during the summer of 1973 in the northern part of the North Sea. The same equipment that laid this line is capable of laying pipe of comparable size in water depths of the order of 600 feet. Engineering studies have shown that this same equipment, with modifications and improvements to the barge anchoring system and the installation of thrusters, will be capable of laying large diameter pipe in water depths of the order of 900 feet. Equipment capable of trenching in water depths as great as 500 feet is presently under construction and is scheduled to work in 420 feet of water in the North Sea next summer.... It must be emphasized that while solutions do exist for laying pipe in water depths as

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*The data base developed by Computer Sciences Corporation for EPA drew heavily on the U.S. Geological Survey's data base on OCS oil and gas accidents. [49]

> great as 900–1000 feet and to trench at a depth of 500 feet there is much additional work to be done to improve the economics of the methods presently envisaged. [54]

Bringing pipelines ashore can result in significant physical and biological impacts. In endorsing the University of Oklahoma recommendation to "develop ways to bring pipelines ashore with minimum environmental disruption," [55] an industry representative stated in a paper prepared for the RFF seminar:

> In critical environmental and congested areas, land use planning and management is desirable to assure that this goal is effectively achieved. Government can provide leadership in developing, compiling, and dispersing general basic scientific and engineering data relating to the surface and sea bottom topography of the OCS and the coastal zones.... Basic information of this type should be compiled and made readily available for all OCS and coastal zone areas. [56]

The RFF seminar concluded: "A bridging of jurisdictional demarcation lines among various Federal and subnational agencies, having supervisory responsibility over different aspects of pipeline and terminal operations, but which provides for adequate representation of all interests involved is absolutely vital." [57]

The Council recommends that the Department of the Interior, in cooperation with other Federal agencies and the affected states, undertake advanced planning for pipeline corridor siting as soon as the location of potentially producing OCS areas is known and designate corridors which avoid or minimize, to the maximum extent possible, intrusion into environmentally sensitive areas in the marine and coastal regions of new OCS areas.

Tankers. Tankers are likely to be used in the Atlantic and in the Gulf of Alaska during the early stages of field production—before pipelines are laid—or on a continuing basis from distant small or medium-size fields for which the economics do not justify investment in pipelines.

As pointed out in Chapter 4, both the frequency and magnitude of oil spills from tankers are higher than from pipelines.* In addition to these accidental discharges, conventional tankers typically discharge oily ballast water and tank washings into the sea before taking on the next cargo of oil. In OCS operations tankers will normally carry oil from the offshore producing field to a shore terminal. On its return voyage to the field (the noncargo or ballast leg), the tanker must take seawater into its cargo tanks to provide stability. This ballast water mixes with the oil left on the tank walls (called clingage).

Discharge of oily ballast water at or en route to the field can be avoided if tanks are cleaned at the cargo delivery terminal before the tanker begins its return voyage. The oily washings can be discharged to oil/water separation facilities ashore. The tanker would then load ballast water into clean tanks and head back to the OCS. Shoreside ballast treatment facilities already exist at many refineries and marine terminals. Although expansion of existing facilities, construction of required new facilities, and additional time to clean tanks and pump oily washings ashore would add to the transportation costs of oil, higher oil prices should make it more desirable to reclaim oil through separation processes than to pump it into the oceans.†

Ships built with special tanks, separate from cargo tanks and used only for ballast, would also prevent the discharge of oily ballast water. Such segregated ballast systems would avoid the need to mix oil and water, except when cargo tanks are periodically cleaned to remove accumulated clingage or prior to drydocking, generally only for the latter.

Segregated ballast systems incorporating double bottoms also insure against oil spills from groundings—the most polluting form of accident in coastal areas, port entranceways, and harbors. [58] A double bottom uses an outer wall for the hull structure and an inner wall for the structure of the oil tanks. The resulting space permits damage to the outer hull should a grounding occur without necessarily affecting the oil cargo tanks, thus preventing spillage. Double bottoms, however, are not feasible on older ships. According to one school of opinion, double bottoms under some circumstances could jeopardize ship safety should an accident occur.

The costs and effectiveness of segregated ballast systems with and without double bottoms have received extensive study recently in preparations leading to the 1973 Conference on Marine Pollution of the InterGovernmental Maritime Consultative Organization. [59] That conference produced an international convention which, when ratified, would require tankers of greater than 70,000 tons deadweight to be constructed with segregated ballast capacity while not requiring double bottoms. However, it is likely that smaller tankers will be used to carry OCS oil to shore. Requirement of segregated ballasts on double bottoms, particularly for smaller tankers, has economic implications for tankers operating in international trade. Consideration should be given to present and future design requirements for international vessels prior to establishing design requirements for U.S. vessels.

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*Most pipelines in the OCS are relatively new; the frequency and magnitude of spills from pipelines may increase unless adequate protective measures are taken.

†Under current international law, tankers are prohibited from discharging any oil into the seas within 50 miles of shore. This rule, largely honored in the breach, would not prevent discharges en route to OCS sites beyond the 50-mile limit.

The U.S. Coast Guard, under the authority of the Ports and Waterways Safety Act, [60] as amended by the Trans-Alaskan Pipeline Act of 1973, [61] is currently in the process of setting standards for the design and construction of tankers in the U.S. coastal trade (which would include tankers used to carry OCS oil to shore).

The Council on Environmental Quality recommends that the Coast Guard require that new tankers in such trade be constructed with segregated ballast capacity preferably with double bottoms when ship safety would not be jeopardized. Existing tankers used to carry OCS oil to shore should be prohibited from discharging oily ballast to the oceans. In addition, the Coast Guard should give serious consideration to requiring new and existing ships to employ advanced accident prevention technologies to improve vessel maneuverability and communications.

Offshore Storage. Chapter 5 discusses the threat of severe storms, earthquakes, and tsunamis to oil storage facilities offshore. Earthquakes and tsunamis would endanger both bottom-standing and floating storage tanks in the Gulf of Alaska. The fixed storage tank would be especially vulnerable to earthquakes. Floating structures—"to safeguard against rupture and potentially serious spillage—could include compartmentalization and double hulls (i.e., essentially the same protective features appropriate to tankers)." [62] The Tetra Tech report states that even floating storage tanks could be seriously damaged if their moorings are broken by earthquake-induced ground motion or by a tsunami. [63]

Severe storms in the Atlantic OCS would also significantly threaten bottom-standing and floating storage facilities. Severe storms in the Georges Bank, where offshore storage would be more likely, are less intense than the hurricanes which are more frequent in the Middle and South Atlantic. North Atlantic storms are comparable to the severe storms in the North Sea, where petroleum companies are gaining experience with both fixed and floating storage.

Discussion of offshore oil storage in the Atlantic and Gulf of Alaska OCS must fully consider the potential impacts of severe storm and seismic conditions. The Council recommends that the Departments of the Interior and Transportation develop detailed performance standards for offshore storage facilities and incorporate them into OCS orders for the new areas.

Oil Spill Response Technologies

Containment. The primary method of oil spill containment is the floating boom. As stated in Chapter 4, the boom's effectiveness is limited because it cannot contain oil under the environmental conditions often found in the OCS—high waves, high wind velocity, and strong currents. Indeed, there are sea conditions in which oil containment is not possible.

Development of more effective containment booms continues and improvements should be expected. But their limited ultimate effectiveness under sea conditions typical of the Atlantic and Gulf of Alaska OCS places even greater emphasis on the importance of prevention.

Cleanup. As Chapter 5 discusses, most mechanical and sorbent cleanup systems "have failed when used at sea." [64] Mechanical cleanup devices are limited for the same reasons that containment booms are limited—rough sea conditions. The Oklahoma team concluded: "At present, these devices are suitable only for calm water and well-defined slicks. Although proponents of particular systems have claimed rough water capabilities, none has been proved effective so far and the prospects are not promising." [65]

Sorbents, which have proved more effective than mechanical devices, also are faced with difficulties. For example, recovery efficiencies of a sorbent vary widely for different types of oil. Although straw is cheap and easily obtainable, it becomes waterlogged and does not have high oil retention ability. [66] Further, cleanup efforts with straw have had to rely on hand labor, which increases both the cost and the time that the oil-soaked straw remains in the water.

Several new sorbent cleanup methods offer some promise of improvement. One would broadcast polyurethane foam over the oil slick and recover, clean, and reuse it in a totally mechanized process. Other methods would use belts or ropes of sorbent material which would be drawn through the oil slick, cleaned on shipboard, and returned to the slick in a continuous operation. [67]

Use of dispersants in U.S. coastal waters is sharply restricted by the National Contingency Plan and other regulations. The primary oil spill response of the United Kingdom Government and industry operating in the U.K. sector of the North Sea, however, is based on chemical dispersants. "Since their first experience with dispersants following the TORREY CANYON, the British have developed dispersants which are a thousands times less toxic than those used then." [68] Industry's planning for oil spill response in the United Kingdom is similar to that in the United States–the operators have organized a Clean Seas Committee for oil spill cleanup. Their equipment in the North Sea, however, is limited to five spray units which are capable of spraying BP 1100X dispersant for 6 hours. The Oklahoma team concluded that "[t]he widespread reliance by North Sea countries on dispersants as their major oil–spill response warrants a review of current U.S. policy. The limitations inherent in mechanical containment and cleanup emphasize the need to consider other alternatives such as dispersants." [69]

An innovation in the United Kingdom oil spill contingency plan is the identification of coastal areas in which the use of dispersants and other cleanup methods is carefully defined because the areas are either ecologically sensitive or support valuable commercial fisheries. [70]

The Council recommends that the Federal Government and industry continue efforts to improve oil spill containment and cleanup methods. The Council recommends further that the Departments of the Interior and Commerce and the Environmental Protection Agency cooperatively consider the identification of critical environmental regions in new OCS areas and the incorporation of appropriate measures into the National Oil and Hazardous Substances Pollution Contingency Plan.

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Chapter 9. Institutional and Legal Mechanisms for Managing OCS Development

The Council's public hearings reflect a belief that regardless of the adequacy of OCS oil and gas technology, the regulation of OCS development can only be as effective as the legal and institutional mechanisms for its implementation. An effective regime for regulating OCS activities should include at least the following elements:

- a rational allocation of regulatory rights and responsibilities and an efficient means of coordination among entities sharing such authority
- provision for ensuring that necessary information is obtained and analyzed prior to regulatory actions and that the public has sufficient information to allow informed participation in the process
- ongoing systematic evaluation of OCS technologies and practices and incorporation into OCS regulations specific requirements necessary for environmentally sound operations
- enforcement of the requirements through effective inspections and sanctions for noncompliance
- means for compensation of injured parties when mishaps occur.

The hearings also revealed widespread public concern about the capability of existing regulatory systems, in many of these respects, to protect the public interest if significant production occurs in vast new geographic areas. The Council therefore contracted with the Environmental Law Institute to analyze the environmental implications of existing legal and institutional arrangements and to consider recommendations for increasing their effectiveness.

ALLOCATION OF REGULATORY RESPONSIBILITIES

International- National

Under the Convention on the Continental Shelf, [1] the United States has exclusive rights over its adjacent continental shelves for the purpose of exploiting their natural resources to a depth of 200 meters and beyond that to where the depth of the superjacent waters "admits of the exploitation of the natural resources." The Third United Nations Conference on the Law of the Sea, the first substantive session of which will convene in Caracas, Venezuela, in June 1974, will further consider coastal state resource jurisdiction. A large majority of the nations which have participated in the preparatory negotiations favor coastal state jurisdiction over the natural resources of the contiguous continental shelf to 200 nautical miles, and many favor jurisdiction to the edge of the continental margin if farther than 200 miles. Under the preponderant view, seabed resources beyond the area of coastal nation jurisdiction will be subject to an international regime.

Coastal nation authority over seabed resources will not, however, be unlimited. The United States has made it clear that the exercise of coastal nation seabed resource jurisdiction must be subject to five conditions to protect the rights of the international community: freedom of other uses, including navigation; compliance with international standards for protection of the marine environment; sharing of revenues with the international community; respect for the integrity of foreign investment; and compulsory settlement of disputes arising under the treaty. [20] At a meeting of the United Nations Seabeds Committee last summer, the U.S. delegation stated that some of these conditions, for example, revenue sharing with the international community, might apply only seaward of the 200-meter isobath.

These five conditions are important to securing a just Law of the Sea regime and are consistent with sound U.S. management of its OCS development. In particular, U.S. domestic environmental standards will be designed to ensure compliance with the international standards, although the United States will be free to set more stringent requirements.

State- Federal

The relationship between the Federal Government and the state and local governments was a pervasive issue at the public hearings. An urgent need for effective Federal-state coordination follows from two related facts. First, as noted by Robert R. Jordan, State Geologist of Delaware, "geologic boundaries and exploration and production activities that are dictated by geologic conditions do not respect political boundaries." [3] Effective regulation of OCS production and related activities therefore requires concerted action at all levels of government.

Second, OCS decisions at one level of government substantially impact upon the interests and activities at other levels. In particular, Federal decisions concerning the OCS will vitally affect what New York Attorney General Louis J. Lefkowitz termed the states' "paramount" interest in protecting "fisheries, harbors, coastal wetlands, beaches and other natural resources from the devastating and lasting damage inflicted by oil spills," [4] as well as their economic and social interests discussed in Chapter 7.

To date over 95 percent of U.S. OCS oil production has occurred off the coast of a single state—Louisiana. The possibility of significant production in other regions underscores the need to develop mechanisms for coordinating the legitimate interests and concerns of affected states.

State Jurisdiction and Authority. Under the Submerged Lands Act of 1953, [5] ownership of the natural resources of lands "beneath navigable waters" of the United States is vested in the respective states of the Union. In general, the act extends "land beneath navigable waters" to 3 miles from the coast. Through subsequent litigation, however, Texas and Florida extended their resource ownership out to 9 miles within their historic boundaries, [6] and in cases currently before the courts, several Atlantic states are attempting to establish ownership far beyond 9 miles. [7] The discussion here assumes state resource jurisdiction to 3 miles.

If state claims for substantially extended jurisdiction are ultimately upheld, the entire system for regulating OCS development in such areas may have to be revised. State regulatory and resource management programs would have to be expanded to an unprecedented scale and mechanisms for interstate planning and coordination devised. In light of present uncertainties, it is unlikely that significant development of contested OCS areas could commence until the courts render a final decision, [8] or until the Federal Government and concerned states negotiate an interim agreement. [9]

Whatever the extent of their resource jurisdiction, the states and their political subdivisions possess important regulatory authorities within it and within related onshore areas. Through measures such as pollution control programs, land use restrictions, pipeline regulation, and zoning and building codes, states and localities can significantly shape OCS development and the construction and use of related nearshore and onshore facilities. Several states have recently enacted legislation providing for state review of development in "environmentally critical areas" and of the siting of key facilities, including powerplants and refineries.*

State authority over OCS-related activities may well be strengthened under existing and proposed Federal legislation. The Coastal Zone Management Act of 1972 [10] provides for state development of management programs for the coastal zone (extending 3 miles from the coast). Once the Secretary of Commerce approves a state program, no Federal license or permit may be granted for any activity (without territorial limitation) which affects the state coastal zone unless the state agrees that the activity is consistent with its management program. In addition, the Congress is currently considering broader land use legislation that would foster state planning and regulatory capabilities concerning major land use decisions beyond the coastal zone.

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*Of the states most likely to be affected by OCS development, only Florida has enacted comprehensive statewide land use legislation. Others—including California, Delaware, New Jersey, Maine, Massachusetts, Oregon, and Washington—have passed laws regulating development in coastal areas.

Federal Jurisdiction and Authority. Under the Submerged Lands Act, state ownership of the resources beneath U.S. navigable waters is subject to the Federal Government's reserved powers, including navigation rights and powers of regulation for security, economic, environmental, and other Federal purposes. The wide range of Federal regulatory statutes and programs that apply to the area of state resource ownership is discussed in the next section of this chapter.

Beyond the area of state ownership the Federal Government has exclusive ownership and authority, subject to the international limitations discussed above. The major Federal statute for exercising control is the Outer Continental Shelf Lands Act. [11] In addition to making the resources of the OCS subject to Federal "control and power of disposition," the act extends the Constitution and Federal laws to the area and the productive activities upon it. Among the Federal laws so extended, of course, is the National Environmental Policy Act. [12]

Developing Means for Coordination

The states' reactions to potential OCS development have varied. Some states apparently welcome it in order to foster economic development onshore. Such a hospitable state reaction may be developing as part of the Coastal Plains Regional Commission study on the feasibility of a deepwater port, sponsored by North Carolina, South Carolina, Georgia and seven oil companies. If the study should find that there is an economic potential for development, then it may also find that there are appropriate sites within the three-state region.

The position of the Massachusetts Special Legislative Commission on Marine Boundaries and Resources, composed of members of the Massachusetts Legislature and appointees of the Governor and state Attorney General, illustrates the reluctance of some states toward OCS development. The Commission has recommended that the state oppose development of the Atlantic OCS pending formulation of comprehensive national energy and marine resources policies. [13]

The array of Federal and state powers indicates a potential for conflict when Federal and state objectives on the OCS diverge. Mechanisms must be developed to identify and resolve such conflicts expeditiously and fairly. The need for coordination, however, is no less urgent when Federal and state objectives coincide. The state regulatory authorities noted above are not mere tools to obstruct OCS development. Rather, they are significant means of protecting and promoting important state interests and have legitimate functions whatever the state attitude toward development.

In exercising its responsibilities to further national interests in the OCS, the Federal Government cannot, in short, "forget the fact that the coastal states themselves have responsibilities to their citizens for the security, economic development, and environmental conditions of their inland and territorial waters as well as the land portion of their coastal zones." [14] The institutional arrangements for OCS management ideally should approximate what Delaware Deputy Attorney General Herlihy termed a Federal-state "cooperation and partnership,... not a big brother, little brother relationship nor one of obstructionism, but rather a healthy respect for each other's needs and interests." [15]

Strengthening State Expertise. In the Atlantic and New England states and in Alaska, there has been little government experience with offshore oil and gas development. Affected states should strengthen their coastal zone management programs by developing special technical expertise on all phases of OCS development and its onshore and offshore impacts. Such augmented state coastal zone management agencies should attempt to ensure that state interests and regulatory authorities are fully coordinated with Federal OCS technical and management activities. Federal agencies should make every effort to cooperate with state coastal zone management agencies on an ongoing basis at all stages of the management process.

Simply establishing technical expertise at the state level and calling on Federal agencies to cooperate will not necessarily yield effective coordination. The decisionmaking process itself must provide regular mechanisms for effecting interaction.

The NEPA Process. Monte Canfield, Jr., Deputy Director of the Ford Foundation Energy Policy Project, has suggested that

> State, local and regional governments must be included in the process of preparing these [environmental] analyses before completion of draft environmental impact statements [on Atlantic OCS leasing]. Expansion of a NEPA-type concept... to insure fully regional participation in the planning process would provide a reasonable approach.... [16]

The NEPA process can be an important focus of Federal-state coordination concerning OCS development. The Council recommends that state coastal zone management agencies be given the opportunity to cooperate with Federal agencies in designing and preparing environmental studies used as input to the environmental review process, in addition to commenting on draft environmental impact statements.

Coastal Zone Management and Land Use Programs. NEPA alone cannot produce comprehensive plans to govern programs for energy development. Several witnesses argued that such comprehensive planning is essential for rational and environmentally sound OCS development [17] and that state participation in such planning is an effective way to ensure adequate accommodation of state interests. Several witnesses further noted that the Coastal Zone Management Act provides a framework for Federal-state cooperation in planning for onshore development induced by OCS operations, [18] particularly with respect to the siting of pipelines, refineries, and other facilities in the coastal zone.

The Council recommends that the state coastal zone management agencies and concerned Federal agencies jointly participate in developing these portions of the plans. Before approving state coastal zone management programs, the Secretary of Commerce should require the state plans to consider refineries, transfer and conversion facilities, pipelines, and other development within the coastal zone related to OCS operations. Under the statute, the plans must provide "adequate consideration of the national interest involved in the siting of facilities necessary to meet requirements which are other than local in nature." At the same time, they should provide adequate consideration of the full range of state interests in the coastal zone.

Because a decision to develop an OCS area may predetermine important decisions concerning uses of the contiguous coastal zone, the Council recommends that states give high priority to completing their plans prior to leasing of OCS tracts for development. The Department of the Interior, in its leasing functions, and the state governments, in exercising their limited veto rights for activities inconsistent with their coastal zone programs, would implement the agreements reflected in the plans.

The Administration's proposed land use bill, which would establish a system similar to that of the Coastal Zone Management Act applicable to noncoastal areas, could provide another vehicle for Federal-state planning for OCS-related development. Upon enactment of such legislation, state land use agencies and concerned Federal agencies should cooperate in developing relevant portions of state land use plans.

There are important limitations to the coastal zone plan as a vehicle for joint OCS planning. The act creates a nonmandatory system, and its financial incentives may be insufficient for reluctant states. In addition, the potentially conflicting interests are so complex as to render impossible fully satisfactory solutions to all issues. At a minimum, however, state coastal zone plans can contribute to more rational decisions concerning OCS and coastal zone uses by improving interaction between state and Federal decisionmakers prior to committing OCS and onshore resources to development.

Federal-Federal

Even a cursory look at OCS regulatory responsibilities within the Federal Government suggests two conclusions. First, there is "a pervasive overall pattern of fragmentation" [19] —many Federal agencies, each with specific missions, have regulatory and operating authority affecting the OCS. Second, there is no formal mechanism for coordinating the exercise of their responsibilities.

Survey of Federal Agency Responsibilities. The Department of the Interior has major responsibility for the OCS. It grants and administers oil and gas leases in accordance with the rules and regulations that it promulgates. Within the department, the Bureau of Land Management (BLM) administers the leasing provisions of the Outer Continental Shelf Lands Act, [20] and the U.S. Geological Survey oversees development of a tract once it has been leased and provides technical information to BLM.

Within the Department of Defense, several agencies operate upon or have jurisdiction over parts of the OCS and the superjacent waters. The Army Corps of Engineers issues permits for any use of navigable waters, including dredging and filling, which may affect navigation. [21] The Secretary of Defense has the power, with the approval of the President, to withdraw any area of the OCS from exploration and development if there is a national defense need. [22]

In addition to his responsibilities under the Coastal Zone Management Act, under the Marine Protection, Research and Sanctuaries Act [23] the Secretary of Commerce may designate marine sanctuaries as far seaward as the edge of the OCS for the preservation or restoration of recreational, ecological, and aesthetic values. He may issue regulations applicable within such sanctuaries, and no permit or license may be granted for an activity within a sanctuary unless he certifies that it is consistent with the act and his regulations.

Within the Department of Transportation, the U.S. Coast Guard has general jurisdiction to "enforce or assist in the enforcement of all applicable Federal laws upon the high seas and waters subject to the jurisdiction of the United States" and to

> promulgate and enforce regulations for the promotion of safety of life and property on the high seas and on waters subject to the jurisdiction of the United States covering all matters not specifically delegated by law to some other executive department. [24]

The Outer Continental Shelf Lands Act charges the Coast Guard with regulating structures on the OCS to ensure safety and to protect navigation. The Coast Guard inspects and certifies drilling rigs, maintains surveillance for oil spills, and enforces provisions of international conventions relating to vessels and fisheries.

The Atomic Energy Commission has recently indicated interest in licensing nuclear generating plants offshore. The Federal Power Commission and the Interstate Commerce Commission have specific authority over pipelines in interstate commerce, the FPC over gas lines and the ICC over common carrier oil lines.

Under the Federal Water Pollution Control Act, [25] the Environmental Protection Agency has comprehensive regulatory authority over discharges of pollutants into U.S. navigable waters, including the territorial sea, and into the high seas from U.S. point sources other than vessels. The act prohibits the discharge of a pollutant into U.S. waters or the ocean (except from vessels) without a prior permit from EPA.

The act further requires that EPA promulgate effluent guidelines to govern the issuance of permits to various industries. Whether OCS development will be the subject of effluent guidelines has not yet been determined. There are no cases concerning the applicability of the permit program to OCS exploitation. The act is susceptible to such a reading, however, and it is possible that EPA may exercise considerable authority over discharges and technology for some OCS operations.

The Potential for Conflict and Coordination. There are two kinds of potential conflict in existing Federal agency authorities. First, there are problems in coordinating regulatory inputs, even when there is no conflict of agency objectives. The transportation of oil and gas from the OCS by pipeline is an example. Both BLM and FPC grant rights-of-way permits, and whether the Geological Survey or the Department of Transportation is responsible for pipeline safety standards is unclear. [26] The basic problem is "that there are too many agencies, each concerned with its own particular aspect of the system, and often these various aspects are not well defined or separable." [27]

The second type of conflict inherent in the existing system stems from the fact that different agencies have different objectives and interests in the OCS. In the absence of formal procedures for planning and coordination,* the inevitable result has been that Federal officials "have tended to promote their own particular programs and respond primarily to the interests and demands of their agency's clients." [28]

As significant new activities commence on the OCS, competing agency objectives may well increase. Within certain geographic limits, deepwater port operation, nuclear powerplants, and oil and gas development and associated pipelines are obviously incompatible. The same is true with respect to those activiities and more traditional uses of OCS areas, such as commercial fishing and recreation. Moreover, there are potential conflicts between many of these uses and environmental objectives.

The problems—fragmented, overlapping agency responsibilities and competing objectives—suggest two types of management reforms. Centralizing Federal responsibility and authority could reduce inefficiencies and duplication. In any event, some mechanism for coordination and planning is needed.

Centralization of authority in one agency. The proposed Department of Energy and Natural Resources should be established. DENR would encompass all programs now in the Department of the Interior and the National Oceanic and Atmospheric Administration, the policy and planning functions of the Army Corps of Engineers, the civilian power functions of the Atomic Energy Commission, and the pipeline safety functions of the Department of Transportation, as well as other programs unrelated to OCS. [29] This centralization of authority could increase the effectiveness of Federal efforts in achieving closely related regulatory objectives in the OCS.†

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*The stated major purpose of the OCS Lands Act is to meet the "urgent needs" for further development of OCS oil and gas deposits. Reflecting the clear assumption that the main use of the OCS will be mineral development, the act does not provide a conflict-resolving mechanism when uses compete.

†Pipelines are a good example, because various divisions of Interior, the Army Corps, and the pipeline division of Transportation presently regulate pipelines.

The DENR could also contribute to long-term Federal planning for the OCS. By itself, however, creation of a "superagency" cannot ensure effective planning and accommodation of sometimes conflicting interests among Federal programs. Their different objectives will remain whether the bureaucracies are federated. In some cases, in fact, effective regulation requires that the agencies remain distinct.* Moreover, when agencies with potentially competing objectives are subsumed in a superagency, there is a risk that interagency criticism, particularly concerning comments on NEPA statements, will be insulated from the public and diminish in usefulness. DENR should adopt procedures to guard against that result.

Improved Federal planning mechanisms. Ideally, comprehensive national energy and land use plans could be developed in advance of decisions concerning the OCS. For the near future, it is perhaps more realistic to focus on development of coordinating and planning mechanisms which allow all interested agencies and parties to participate in decisions concerning proposed uses of an OCS area. [31] The basic object should be to ensure that Federal decisionmakers are aware of all the impacts of a proposed OCS use and its implications for other possible uses of the same or affected areas. Experience over the long run may indicate the desirability of creating a new process geared specifically to OCS decisions, but the most practical near-term solution is to use the existing environmental impact statement process created by NEPA.

The Council recommends that impact statements on environmentally significant OCS activities include in the discussion of "the range of potential uses of the environment" analyses of possible alternative uses of specific OCS and nearshore and onshore areas. In addition, such statements should include discussion of onshore impacts. In commenting on draft statements, Federal agencies, states, and interested parties should give particular emphasis to those issues.

OCS decisionmaking could also be enhanced through regional, programmatic impact statements. Programmatic statements have proven valuable in other contexts and are encouraged under the CEQ Guidelines. The Council recommends that programmatic statements be prepared on a regional basis by all Federal agencies proposing environmentally significant activities on the OCS. Comprehensive OCS planning could be approached through reconciling various agency statements in the circulation and comment process.

In sum, the Council believes that the environmental impact statement process is a flexible tool which can be used to achieve policy goals in addition to compliance with NEPA. Although NEPA does not require comprehensive OCS planning, it can significantly contribute toward that end if adapted as recommended above. Of course, NEPA remains the basic instrument for assessing primary environmental impacts, and its ability to perform that function should be significantly improved by BLM's projected environmental baseline and monitoring studies for newly developed OCS areas.

DATA NECESSARY TO EFFECTIVE ENVIRONMENTAL REGULATION

The ability of the existing OCS regulatory system adequately to acquire, analyze, and disseminate geophysical and geological data was questioned at the public hearings and in the Oklahoma study. The Oklahoma researchers concluded that limited data curtail effective administration of OCS leasing [32] and that restrictions on public disclosure of data may "inhibit the effectiveness of the public review process." [33] Several witnesses expressed concern about the fact that much of the information accumulated by private OCS developers is considered proprietary and therefore unavailable for public, and sometimes Government, scrutiny. [34] Industry's reluctance to release certain information is a natural outgrowth of the OCS leasing program, which is predicated on competitive initiative.

The Council considered the availability of data to the Government and the public at various stages of development, taking as a case study the most recent lease sale held by BLM–the sale of tracts off Mississippi, Alabama, and Florida (MAFLA). [35] Because the MAFLA region is a virgin OCS area, it is particularly pertinent here.

Tract Selection

Once an OCS area has been tentatively scheduled for leasing, oil companies gather data necessary to nominate specific tracts for inclusion in the lease sale.* Such data are normally obtained by "speculative surveys" undertaken by private seismic surveying companies, the results of which are sold on an open market, and by "group shoots" undertaken jointly by several oil companies, the results of which they share. Because USGS has only a minimal seismic surveying capability, it purchases processed data from these two sources. The data are purchased on a proprietary basis because industry believes that public disclosure would destroy the incentive for financing cooperative surveys.

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*The Oklahoma study concluded, for example, that it is desirable to retain the separation of promotion functions (in BLM) and safety and environmental functions (in USGS) and that "if changes are to be made, it should be to strengthen the competition between them." [30]

Typically, however—and the MAFLA sale was not an exception—USGS does not acquire industry's interpretations of the processed data, from which real competitive advantages may be obtained. Rather, USGS analyzes the data that it acquires from industry. These analyses are not made public.

Individual companies nominate for inclusion in lease sales those tracts which they believe to have the greatest development potential. As in the MAFLA, the Government generally selects tracts from among those nominated by industry. Pursuant to an agreement between BLM and USGS, the "overriding factor" in that selection is to ensure adequate supplies of oil and gas. [36] The agreement indicates that environmental considerations are reviewed in tract selection, but it states that environmental analyses of detailed seismic data are made only "after tracts are selected."†

Lease Sale

The Interior Department prepares an environmental impact statement prior to each lease sale. The draft statement on the MAFLA sale indicates, however, that the only geophysical information available to BLM at that stage was the wide-area seismic survey data purchased from speculative surveys—data obtained by industry for locating the most productive tracts, not for assessing geologic hazards.

The draft states that "high resolution geophysical data," which are useful in assessing geologic hazards, are "generally not gathered until the tracts to be offered for lease are announced" and hence are "not presently available to contribute to" the environmental analysis. Such data, the draft indicates, will be purchased on a proprietary basis by USGS only after completion of the *final* impact statement. Although high resolution data are obtained prior to actual leasing, USGS does not analyze them for the purpose of locating unsafe structures until afterward.‡

Assessment of the Present System

Timing. Until after the lease sale, USGS and BLM acquire and analyze data in order to locate the most productive tracts and maximize the Government's economic gain from the disposition of those tracts. Although high resolution seismic survey data are available to the regional OCS supervisor prior to his final approval of drilling, the range of options available to the Government has by that stage been significantly narrowed. The question becomes one of where to drill within a leased tract rather than whether the entire tract is basically suitable from an environmental and safety perspective. Special engineering safeguards can be required in unusually hazardous tracts, but by waiting until the postlease stage to analyze geologic hazards, USGS relies heavily on its regulatory capability and the good faith of operators to make allowances for such conditions.

The present system, in short, permits environmental risks which a prudent regulatory official might well choose to avoid if he considered all available information earlier in the process. The risks inherent in such an approach are greatly increased in areas such as the Gulf of Alaska, where subsurface geologic structures are more varied and more hazardous than have heretofore been encountered.

Government Information Requirements. In practical effect, the industry has determined the information requirements of Government for OCS leasing. This is the inevitable consequence of a system in which USGS has only limited geophysical data-gathering capacity and must rely on industry data.

Industry's incentives, however, are not always sufficient to generate all the data necessary for effective environmental regulation. Prior to a lease sale, industry understandably concentrates on obtaining and analyzing data that locate petroleum deposits. The unavailability of high-resolution seismic data to USGS before completing the final environmental impact statement is due in part to the fact that the companies have little economic incentive to acquire such costly data until after tracts are finally selected. After the lease sale, moreover, there is little economic incentive for industry to acquire data solely for assessment of environmental risks.

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*In initially scheduling an OCS area for future development, the Government's knowledge depends in large part on whether the tracts under consideration are within a previously developed region. In such regions, the Government will have significant geologic and geophysical data from the operating reports that industry is required to submit to USGS. In virgin areas like MAFLA, on the other hand, USGS has little geological or geophysical data at the scheduling stage.

†In the MAFLA sale, no tracts were eliminated at this stage on the basis of environmental hazards revealed through geologic or geophysical information.

‡No tracts were deleted from the MAFLA sale on the basis of such data.

Public Information. The fact that the Interior Department treats industry data as proprietary "severely restricts the effectiveness of the public review process," particularly in commenting on environmental impact statements. [37] Although there may well be sound reasons for withholding some data in some circumstances, the competitive justification for a blanket prohibition of public disclosure is not clear.

For example, it is not clear that the release of processed seismic reflection data would substantially jeopardize the competitive positions of the oil companies in relation to the Government or to each other, because they routinely share group shoot data with the Government and among themselves.* Moreover, because competition dissipates after a lease sale, the justification for continuing to withhold exploratory data after lease awards is unclear.

Some geological and geophysical information–for example, data concerning subsurface geologic hazards relevant primarily to safety and environmental concerns–would seem competitively nonsensitive. The present definition of proprietary data does not include criteria for such exceptions.

Even without making more information available to the Government or the public, significant benefits could be obtained through USGS analysis of potential geologic hazards prior to tract selection. In testimony before the House Judiciary Committee on Jan. 24, 1974, Interior Secretary Rogers C.B. Morton announced what appears to be a step in the right direction–"a new two-tier nomination system":

> Under this system, industry will first rank the regions they think are most favorable. The public will be invited to identify environmental conditions and problems in these regions. The Interior Department will use the industry and environmental rankings of regions... to select the most promising regions for early development.... Even before industry nominations of regions have been received, environmental analysis will be begun for some new regions already identified as highly promising. [38]

Numerous alternatives for making more information and analyses available to the Government and the public were suggested in the hearings and the Oklahoma study, ranging from increased Government acquisition of industry data and analyses on a proprietary basis to Government collection and publication of geological and geophysical data. As the Oklahoma study observes, the OCS system is complex, and any change, such as having Government collect its own data or establishing new rules concerning public disclosure, will produce changes in other parts of the system as well, such as "possible effects on the seismic services industry [and] competitive bidding." [39] These effects deserve careful study before changes are implemented.

The Council recommends that the Department of the Interior determine the kinds of information and analyses necessary for adequate assessment of environmental factors at all stages of leasing and development. The department should take appropriate measures to obtain such information, including acquisition and analysis of high-resolution, near-surface seismic reflection data† for the purpose of determining the nature and magnitude of geologic hazards prior to tract selection.

The Council also recommends that the Department of the Interior consider the competitive consequences, at different stages in the process, of requiring disclosure of certain industry data and analyses. The department should weigh those consequences against the benefits to be obtained and develop standards for governing such disclosure. In making that balance, it should consider particularly the need for informed public participation in the NEPA process.

DEVELOPMENT OF STANDARDS

Chapter 8 examines in detail technical standards for minimizing the environmental effects of OCS development. This section considers the general nature of those standards and how they are developed, without reference to their technical merits.

Under the OCS Lands Act, the Secretary of Interior has broad authority to issue rules and regulations for

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*Possibly, however, such disclosure would undermine the incentive for private speculative surveys.

†The measures for obtaining such information–such as the Government's collecting data or requiring industry to submit new types of data with tract nominations–should be considered in light of the possible effects noted above.

Federal lessees. Current regulations [40] establish USGS responsibility for overseeing all aspects of OCS oil and gas development. USGS has divided the OCS into regions, each under the authority of an Area Oil and Gas Supervisor, who has jurisdiction over "drilling and production operations... and in general, all operations conducted on a lease by or on behalf of a lessee." [41] Each area supervisor has issued OCS orders applicable in his region. In addition, he issues field rules tailored to more limited areas.

Under department regulations, operators must submit an overall operating plan before exploratory drilling and before production. A permit is required for each well drilled under an exploration or production plan.

Although the regulations deal with environmental concerns, they do so in general terms,* relying on regional OCS orders to develop specific operating standards. However, the OCS orders for the Gulf of Mexico and the Pacific regions reflect varying degrees of precision in setting forth requirements.† Recent studies conducted by the National Academy of Engineering and the National Aeronautics and Space Administration [42] criticized existing OCS orders for their lack of exact specifications for safety equipment and procedures. The experience of other Federal agencies—for example, the Federal Aviation Administration and the Atomic Energy Commission—indicates that precise regulation is possible for technologies which are certainly no less complex than OCS operations. In Chapter 8, detailed performance requirements are recommended for specific techniques and practices.

Instead of limiting consideration to technologies and practices within the present "state of the art," the Council recommends that the Department of the Interior determine what environmental protection is necessary in the public interest and then require the development and use of technologies to achieve it. This is especially important if large-scale production commences in the Atlantic and Alaska OCS, where new environmental risks may be present.

ENFORCEMENT

The effectiveness of technical standards for OCS operations depends in large part on the enforcement system. That system must include effective means for discovering noncompliance and sanctions sufficient to ensure remedial action and deterrence.

Inspection

The effectiveness of the inspection system depends largely on the frequency of inspections, the number and competence of inspection personnel, the existence of regular inspection procedures, and the extent to which such procedures are in fact observed. A June 1973 General Accounting Office report, [43] which was based on analyses of random OCS inspection reports and onsite observations during fiscal year 1972, found the present system inadequate in many of these respects.

Of 50 wells selected at random in the Gulf of Mexico, GAO found that only half had been inspected during drilling operations. Although OCS Order No. 8 requires a complete inspection when production begins and every 6 months thereafter, only 4 of 20 randomly selected structures had been inspected when production began, and the average inspection frequency for 97 producing structures was approximately once every 10 months. The final environmental impact statement on the MAFLA lease sale indicates that the situation has not significantly improved: "All producing platforms are inspected at least once a year," and "the frequency rate for platform inspections is approximately once every nine months," not every 6 months as required by OCS Order No. 8.

The GAO found that the number of engineers and technicians on USGS inspection teams has increased nearly threefold since 1969. The MAFLA impact statement states that the inspection staff will be further enlarged, and substantial increases would seem necessary if large-scale production commences in new areas. GAO also found that except for occasional industry-sponsored technical courses, USGS inspectors are trained on the job.

After accompanying USGS inspectors for 15 days, the GAO team observed that

> the Survey [USGS] had not established adequate instructions for certain types of inspections. Also, in some instances (1) not all of the required steps were performed, (2) uninspected equipment was reported as inspected, (3) items of noncompli-

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*Lessees, for example, must take "necessary precautions" to keep wells under control, must utilize equipment "necessary to insure the safety of operating conditions," and "shall not pollute land or water or damage the aquatic life of the sea."

†For example, Order No. 2 for the Gulf of Mexico region specifies precise requirements for surface casing, but Order No. 7 for the same region, which deals with pollution and waste disposal, is much less specific. It states that wastes "which may be harmful to aquatic life" must be "treated to avoid disposal of harmful substances."

ance were not noted in the inspection reports, and (4) inspection reports were not prepared for certain types of OCS operations. [44]

Further, inspectors often did not determine whether operators were following their drilling plan specifications.

Sanctions

An effective enforcement system must include sanctions for noncompliance which are adequate to deter violation and are conscientiously applied. The GAO found that prescribed enforcement actions were often "altered" by inspectors if in their judgment the circumstances so warranted. At the time of the GAO report inspectors had no specific guidance concerning the circumstances under which they could alter or waive prescribed enforcement action. The MAFLA impact statement indicates, however, that inspectors are now instructed that any deviations must be authorized by the Chief of the USGS Conservation Division.

Concerning deterrence* a 1972 USGS Lease Management Study found that the threat of production losses was insufficient to ensure compliance. Such losses "did have an impact, but instead of increased compliance, industry's response led to decreasing the length of shut-ins by stockpiling parts and making effort to correct the INC [Item of Noncompliance] during inspection." [45] In order to deter violations rather than merely shorten the time that operators take to correct noncompliance, the USGS study considered additional enforcement measures--increasing royalty payments, canceling leases, and limiting lease bidding to "clean" and "safe" companies. The study concluded that only punitive shutins, i.e., fixed shutin periods for certain violations, and administrative fines would be effective in the short run. The Council recommends that the Secretary of Interior propose such sanctions.

The Council also recommends that the Department of the Interior determine the frequency and type of inspections necessary to verify compliance during all phases of OCS operations. It should establish inspection teams and procedures in light of those determinations and the scale of OCS development in various regions. State agencies should be allowed to participate in these inspection efforts.

In addition, the USGS should, as the GAO recommended, establish a formal training program for the inspection staff. A newly created API-USGS Committee on Offshore Safety and Anti-Pollution Training and Motivation might contribute to such a program.

Citizens suit provisions, which allow interested persons to sue to remedy violations of Federal regulations or permit conditions, can provide a useful compliance mechanism. [46] The Council recommends that the Secretary of Interior seek the establishment of such a right under the OCS Lands Act.

LIABILITY AND COMPENSATION

Even with the best technological safeguards, some OCS accidents are inevitable. Several witnesses at the public hearings recommended that the operators, not private citizens, bear the costs of pipeline failures, tanker casualties, and other accidents. [47]

Existing Liability

Interior Department regulations issued under the OCS Lands Act make lessees financially responsible for the "total removal" of pollution resulting from drilling and production operations. If the lessee does not take necessary cleanup measures, the area supervisor is authorized to do so at the lessee's expense. [48]

Similarly, the Federal Water Pollution Control Act [49] prohibits certain discharges of oil and hazardous substances and authorizes Federal Government cleanup at the operator's expense unless the operator does so "properly."† These provisions do not apply, however, to offshore facilities beyond 3 miles of the coast or to any pollution damage beyond 12 miles.

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*Existing sanctions include written warnings for "items that do not present any immediate danger to the safety of life and property or to environmental quality"; zone shutins for "items that present an immediate danger, but which can be eliminated by shutting down the zone until such time as the lease operator has complied with the rules and regulations"; pipeline shutins, i.e., zone shutins applied to pipelines; partial platform shutins for "items that present an immediate safety hazard but which can be eliminated by shutting down part of the platform, usually a single piece of production equipment, until such time as the lease operator has complied with the regulations"; platform shutins, i.e., all production is shut down until compliance is assured; and recommended fines, applicable only when the operator fails to install subsurface safety devices.

†State removal efforts are reimbursable as well, if performed pursuant to the National Oil and Hazardous Substances Pollution Contingency Plan established under the act. There are limited exceptions to the operator's liability (e.g., acts of God), and unless the discharge resulted from his willful negligence or misconduct, there are ceilings on the amount of recovery.

Neither the Interior regulations nor the Federal Water Pollution Control Act provides for compensation to damaged private parties. The regulations state that such cases are governed by "applicable law," and the FWPCA merely indicates that it does not affect the operator's obligations to third parties.

At least three states—Maine, Massachusetts, and Florida—have enacted legislation providing for oil pollution liability. [50] Unlike the Federal measures, all three allow private parties recovery for pollution damage within state jurisdiction (i.e., within 3 miles of the coast).* The Maine statute establishes a $4 million revolving fund financed by license fees on terminal facilities to ensure quick payment of claims, and Florida requires owners of ships and facilities to establish evidence of financial responsibility. The U.S. Supreme Court recently upheld the Florida statute, holding that there is "no constitutional or statutory impediment" to state liability requirements "concerning the impact of oil spillages on Florida's interest or concerns." [51] The Court did not rule on possible limitations on the amount of recovery.

Pollution damage resulting from the Trans-Alaska Pipeline and related tanker traffic will be compensable under the Trans-Alaska Pipeline Authorization Act. [52] It makes the holder of the pipeline right-of-way "strictly liable to all damaged parties, public or private," for pollution damage resulting from pipeline activities. For public and private damages resulting from vessel discharges of oil loaded at a pipeline terminal, the vessel owner is strictly liable up to $14 million, and the act creates a fund financed through levies on the industry to pay supplemental damages up to $100 million.

Two international conventions negotiated under the auspices of the InterGovernmental Maritime Consultative Organization (IMCO) deal with liability and compensation for vessel-source oil pollution damage. The 1969 International Convention on Civil Liability for Oil Pollution Damage places strict liability on shipowners for pollution damage in the territory or territorial sea resulting from the discharge of persistent oil from vessels carrying such oil in bulk.† The 1971 International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage creates a supplemental fund, financed through levies on oil receivers, to pay damage claims when the Civil Liability Convention is inadequate.‡ Neither convention has been ratified by the United States.

In addition to liability under statutes and treaties, some OCS-related pollution damage may be compensable under various common law liability doctrines. However, such recovery raises unresolved legal issues and difficult problems of proof.

Assessment

There is no private party recovery under Federal law for pollution damage from non-vessel sources or non-oil-vessel sources. The states are free to provide for such recovery for damage within 3 miles, but most have not done so.

Although additional state action may be useful, economic and administrative considerations in ensuring adequate compensation and financially responsible defendants make uniformity desirable. The Federal Government should carefully consider the full economic and environmental implications of various types of liability—fault or no-fault—and various means of ensuring adequate compensation such as liability insurance for operators or a revolving fund financed through charges on operators. In particular, consideration should be given to following the precedent of the Trans-Alaska Pipeline Authorization Act. The Council recommends that a comprehensive Federal liability system for OCS-related oil spill cleanup and damages be established through new legislation.

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2. Statement by John R. Stevenson, U.S. Representative to U.N. Seabeds Committee, Aug. 10, 1972, U.S. Department of State press release.
3. Statement at public hearings conducted by the Council on Environmental Quality, Ocean City, N.J., Oct. 12, 1973, p.3.
4. Statement at public hearings conducted by the Council on Environmental Quality, Mineola, Long Island, N.Y., Oct. 3, 1973, p. 2.
5. 43 U.S.C. §1301-15.

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*The Massachusetts statute covers discharges beyond 3 miles to the extent that they cause damage within 3 miles.

†There are some exceptions and a ceiling on damages. The convention preempts other recovery against the shipowner.

‡There is a $36 million ceiling on liability.

6. See *United States* v. *Louisiana*, 363 U.S. 1 (1960), *rehearing denied*, 364 U.S. 856 (1960); *United States* v. *Florida*, 363 U.S. 121 (1960).

7. See *United States* v. *Maine et al.*, No. 35 Original, April 1969.

8. Mineola public hearings, supra note 4, at 2.

9. See University of Oklahoma Technology Assessment Group, *Energy Under the Oceans* (Norman: University of Oklahoma Press, 1973), p. 209.

10. 16 U.S.C. §1451.

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12. 42 U.S.C. §4321.

13. Statement by Massachusetts State Senator Bulger at public hearings conducted by the Council on Environmental Quality, Boston, Sept. 18-19, 1973.

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17. Statement by Mrs. Barbara M. Heller at public hearings conducted by the Council on Environmental Quality, Boston, Sept. 18-19, 1973.

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19. *Energy Under the Oceans*, supra note 9, at 186.

20. 43 U.S.C. §1331.

21. 43 U.S.C. §1341 (d).

22. 32 C.F.R. §252.4 (a) and (e).

23. 16 U.S.C. §1431.

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25. 33 U.S.C. §1227.

26. *Energy Under the Oceans*, supra note 9, at 198.

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31. Id. at 189.

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33. Id. at 153.

34. Hon. Marlow W. Cook, Dr. James Davis, Alfred S. Forsyth, Mrs. Barbara M. Heller, Ronald Pederson, and Dr. Glen Stice.

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37. Mrs. Barbara M. Heller, note 17 supra.

38. Statement by Hon. Rogers C.B. Morton, *Hearings Before the Subcommittee on Immigration, Citizenship and International Law, House Judiciary Committee*, Jan. 24, 1974, Ser. No. 93-31 (Washington: U.S. Government Printing Office, 1974), p. 69.

39. *Energy Under the Oceans*, supra note 9, at 157.

40. 30 C.F.R. §250.

41. Id. at §250.10.

42. Morris K. Dyer, et al., *Applicability of NASA Contract Quality Management and Failure Mode Effect Analysis Procedures to the USGS Outer Continental Shelf Oil and Gas Lease Management Program*, (Washington: National Aeronautics and Space Administration, 1972), pp. 64-65; National Academy of Engineering Marine Board, Panel on Operational Safety in Offshore Resources Development Safety, *A Review of Technology and Regulation for the Systematic Minimization of Environmental Intrusion from Petroleum Products* (Washington: National Academy of Engineering, 1972), p. 4.

43. General Accounting Office, Report to the House Conservation and Natural Resources Subcommittee, Committee on Government Operations, "Improved Inspection and Regulation Could Reduce the Possibility of Oil Spills on the Outer Continental Shelf," June 1973.

44. Id. at 22.

45. Department of the Interior, Geological Survey, "Outer Continental Shelf Lease Management Study, Final Report," May 1972, p. 432.

46. See, e.g., §505 of the Federal Water Pollution Control Act, note 25 supra.

47. Hon. Louis J. Lefkowitz and Dr. Glen Stice.

48. 30 C.F.R. §250.43 (b).

49. 33 U.S.C. §1321.

50. Oil Discharge Prevention and Pollution Control Act of 1970, 38 Me. Rev. Stat. Ann. §541-57 (Supp. 1973); Massachusetts Clean Waters Act, Mass. Gen. Laws Ann., Ch. 21 §27 (1973); Fla. Laws 1970, Ch. 70-244, Fla. Stat. §376.011-376.21 (1961).

51. *Askew* v. *American Waterways Operators, Inc.*, 411 U.S. 325 (1973).

52. 43 U.S.C. §1651.

ISSUES IN THE ASSESSMENT OF ENVIRONMENTAL IMPACTS OF OIL AND GAS PRODUCTION ON THE OUTER CONTINENTAL SHELF

A Critique of
"OCS Oil and Gas – An Environmental Assessment,"
a Report to the President prepared by the
Council on Environmental Quality

The Review Committee on the Environmental Impact of Oil and Gas
Production on the Outer Continental Shelf
of the
Environmental Studies Board
National Research Council

National Academy of Sciences
National Academy of Engineering
Washington, D.C., 1974

NOTICE

The project which is the subject of this report was approved by the Governing Board of the National Research Council, acting in behalf of the National Academy of Sciences. Such approval reflects the Board's judgment that the project is of national importance and appropriate with respect to both the purposes and resources of the National Research Council.

The members of the committee selected to undertake this project and prepare this report were chosen for recognized scholarly competence and with due consideration for the balance of disciplines appropriate to the project. Responsibility for the detailed aspects of this report rests with that committee.

Each report issuing from a study committee of the National Research Council is reviewed by an independent group of qualified individuals according to procedures established and monitored by the Report Review Committee of the National Academy of Sciences. Distribution of the report is approved, by the President of the Academy, upon satisfactory completion of the review process.

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Summary of Major Conclusions and Recommendations

1. THE CEQ REPORT

The CEQ Report is a commendable and useful first step toward the development of new federal policies for OCS oil and gas resources in the Atlantic and the Gulf of Alaska. The Report is aptly described by the CEQ as an "agenda for action" and it will provide information and analyses useful to evaluations of future OCS programs and projects. It does not purport to be an environmental impact statement on OCS leasing in the Atlantic or Gulf of Alaska; rather, it will serve as a helpful guide to the impact statement processes.

The Committee recognizes that under the National Environmental Policy Act any federal decision to develop OCS oil and gas resources in these two regions must follow the preparation and review of detailed impact statements to forecast the kinds of environmental changes that will occur and to assess the alternative policies available. Separate impact statements should be prepared for the leasing program as a whole, for the aggregate developments within each region, and for each specific lease sale.

While the CEQ Report is a responsive advisory statement on future environmental policies regarding OCS oil and gas, the Committee wishes to stress the study's limited mandate as well as its understandable avoidance of consideration of alternatives to our current national energy policy. At the outset, for example, the Report accepts without analysis the advisability and practicality of Project Independence, the federal program to achieve energy self-sufficiency by 1980. Most energy experts believe that such a program will entail immense economic disruptions and environmental costs and may not even be technically possible. Further, the Report accepts OCS development as an exclusive activity of the private sector without examining various legislative proposals for a federal oil development corporation or for other public development entities such as exist in other countries that produce oil and gas. We concur with the conclusion of the CEQ Report that development of OCS oil and gas and environmental protection need not be mutually exclusive objectives. However, the Report relies on the precept that continued annual growth in energy availability to the year 2000 and beyond is accepted public policy. The Committee believes that these assumptions should be challenged by all concerned with the development of a viable, long-term national energy policy.

2. RESOURCE INFORMATION

The Committee recommends that the federal government obtain and make public all information about natural resources necessary for informed decision-making on national energy policy. In particular, the federal government should publish the best detailed estimate of our OCS reserves of oil and gas, as has traditionally been done for other energy resources such as coal and oil shale. Existing sources of information can be used and additional field programs initiated applying advanced technologies such as the "bright spot" technique as discussed in Section III. The data can be obtained either by government agencies directly or by purchase from commercial sources. We recognize that implementation of this recommendation will transfer to the public the burden of exploration now borne directly by industry, but we suggest that appropriate adjustments in bidding and leasing policies can be devised to recover this cost equitably.

3. RANKINGS BY RELATIVE DEGREE OF ENVIRONMENTAL RISK

The Committee concludes that the criteria used by the Council in ranking potential OCS development areas by the degree of relative net environmental risk are inadequate and incomplete. We agree that developing the Gulf of Alaska areas entails high risk, but question the bases for the relative ratings of Atlantic OCS areas. The ranking criteria used were limited to the predicted probability and simulated trajectories of oil spills, the incidence of unusual natural phenomena in each area, the distance of the resource development sites from shore, regional economic benefits of related onshore developments as measured by employment and value of production, and projections of regional energy needs. The bases on which predictions of the movement of oil spills have been made are uncertain and therefore these results should be viewed as having only limited utility. Moreover, a more adequate consideration would have included additional criteria for which data already exist: the effects of spills and discharges on offshore marine environments, evaluation of national economic benefits and costs, and alternative uses of OCS resources. There are also intangibles that should be assessed, such as the social costs and benefits to the quality of life that result from resource development. The Council's relative ranking of areas might have been different if they had included such criteria. For example, if a measure of the importance of present and potential alternative uses of the OCS for both domestic and foreign commercial fishing had been considered, the Georges Bank might not have been ranked as the area subject to the lowest relative risk.

4. ENVIRONMENTAL PROTECTION

Stringent environmental control measures are mandatory in any OCS development. We concur with the recommendations of the CEQ Report for improving technology and for ensuring its effective use through appropriate regulation and enforcement. Policies for regulation and enforcement should rely as extensively as possible on incentives to the operators to maintain high levels of environmental protection and high standards of safety in their own interest. The full cost of implementing the measures recommended should be included in the costs of the crude oil and gas produced. Some additional related recommendations of the Committee are presented in Section V of this critique.

5. COASTAL ZONE MANAGEMENT

The Committee suggests that decisions concerning the development of OCS oil and gas resources involve the broadest possible base of participation by individual citizens and local, state, and federal agencies. In particular, we concur with the recommendations of the CEQ Report that state coastal zone management agencies be given full opportunities to cooperate with federal agencies in designing, preparing, and reviewing environmental impact statements and that these agencies should jointly participate in developing state coastal zone plans.

The Coastal Zone Management Act of 1972 encourages but does not require states to develop such plans. Development of OCS oil and gas is clearly a national concern, but its implementation must be carried out in ways that conform with state regulations and coastal zone plans. The impacts of OCS development on coastal zones, including the impacts of ports and related industry, can be minimized by careful planning. Unfortunately, few states or local jurisdictions, if any, have adequate capacity to undertake and sustain comprehensive planning of the scope and quality required to realize the onshore development opportunities and minimize the risks inherent in OCS resource use. Therefore, it is imperative that an open, effective institutional planning structure be created and adequately funded that will utilize the capabilities of federal, state, and local governments. Decisions within that process on land use planning and regulation should reflect national as well as regional environmental, economic, and energy interests.

I. Purposes

In his message to Congress of April 18, 1973, President Richard M. Nixon requested that the Council on Environmental Quality (CEQ) undertake, in consultation with the National Academy of Sciences (NAS) and Federal agencies, a study of the environmental impacts attendant to oil and gas production on the outer continental shelves (OCS) along the Atlantic coast and in the Gulf of Alaska.

As a result of this request, the NAS, through the Environmental Studies Board (ESB) of the National Research Council of the National Academies of Sciences and Engineering, convened an *ad hoc* panel in May, 1973, to review the outline of the study proposed by the CEQ. Subsequently, the CEQ contracted with the NAS to provide for a formal consultative and review committee under the auspices of the ESB and its parent body, the Commission on Natural Resources. The members of this committee are listed in Appendix 1.

One purpose of the consultative and review committee of the NAS was to provide for the CEQ a continuing review for the duration of the study of the procedures, work plans, contractors' reports and other documents obtained by the CEQ for the purposes of the study. In addition, a critique of the final report of the CEQ was to be prepared and submitted to the President with the CEQ Report. The appointment of the NAS committee, its deliberations, and the formulation and review of its reports were all conducted according to standard procedures of the Academy.

In the course of discharging its duties, the NAS committee met jointly with the staff of the CEQ on three occasions, once to review the CEQ study plan, once to review the work of contractors and a proposed outline of the CEQ report, and once to critique their draft report. The Chairman of the committee and members of the Council met twice to discuss the study and the role of the NAS in it. Several members of the committee and the staff participated in a site visit to oil and gas facilities in the Santa Barbara Channel. The NAS Project Officer also participated, at the invitation of the CEQ, in a field trip to offshore and onshore facilities in the Gulf of Mexico arranged for the Council members and staff by the United States Geological Survey. The respective staffs of the NAS and the CEQ maintained close contact throughout the period of the study.

This critique is the result of the committee's activities under the terms of the contract between the CEQ and the NAS. Its purpose is to provide a guide for assessing the environmental problems attendant to development of OCS oil and gas resources and the effectiveness with which they were treated in the CEQ Report. Most of the direct environmental impacts have been addressed in the CEQ Report. However, some broader issues of national policy on the development and management of OCS oil and gas resources were not covered. Recognizing the limits of the study as mandated to the CEQ, the NAS Committee independently chose to address in its critique those associated problems that it believes to be important and in the public interest.

The critique is organized to address the following major issues. Section II describes a perspective of OCS oil and gas in the context of national energy policy. Section III assesses present knowledge of available resources and environmental conditions. Section IV describes the nature of the ecological and regional economic impacts attendant to OCS development. Section V assesses the evaluation of risk and the adequacy of technology. Section VI discusses institutions and public policy.

The committee acknowledges the assistance and cooperation of the staff of the CEQ in the conduct of its work, in particular the Study Director, Dr. Stephen J. Gage, and the Study Coordinator, Mr. Bruce A. Pasternack.

II. OCS Oil and Gas in the Context of National Energy Policy

FUTURE ENERGY SUPPLY AND DEMAND

Any projection of the growth in demand for energy in the United States contains substantial amounts of guesswork. The CEQ Report has done a service by emphasizing the wide range of values that can emerge from plausible assumptions. The Report presents three estimates of total energy consumption in the United States in the years 1985 and 2000.[1] These estimates project consumption for the year 2000 to be 192 (high), 166 (medium), or 121 (low) quadrillion British thermal units (Btu). By comparison, consumption in 1973 was 75 quadrillion Btu. In our view, the medium and low estimates probably bracket what will happen, since the high estimate accounts for neither potential energy conservation nor the effects of increasing energy costs. The medium estimate is consistent with an annual growth rate in per capita consumption of about 1.8 percent, which is slightly greater than the average annual growth rate during the last 25 years. It is also consistent with an annual improvement in the efficiency of energy use measured by the real Gross National Product produced per Btu consumed—of approximately one-half of a percent, about what has been achieved on the average in the past two decades. The low estimate would require a lower growth rate in per capita consumption and greater emphasis on efficient energy use. There are no technical obstacles to achieving more economy in energy use, but the implied restrictions on energy intensive forms of consumption may be painful.

Substantial additional supplies will be required to attain any of these levels of consumption of energy. Indeed, because oil and gas reserves are subject to continual depletion, the amount of new reserve that must be found each year exceeds the rate at which demand for oil and gas grows. There are in the ground ample alternative sources such as coal and oil shale for meeting the expected demand for energy for the next 100 years, even without imports. The problems are getting them out of the ground and using them in environmentally acceptable ways. Large reserves of coal, oil shale, petroleum, and natural gas can be supplemented by nuclear power and such novel sources as solar and geothermal energy.

The pattern of increasing energy prices will probably continue and may lead to so large an expansion of production of oil and natural gas from current production sites that much of the anticipated growth in demand for these fuels can be met from these sources alone. Such an expansion in production, however, yields net economic benefits largely at the margin. New reservoirs of oil or gas have the potential for producing very much larger net economic benefits per unit of output; exploration in new areas frequently results in the discovery of reserves of oil or gas that can be produced and transported to a market at a cost considerably below the market price. This potential for large net economic benefit is one of the most attractive features of OCS exploration, and determining the **extent of OCS oil and gas reserves should be a priority goal for the nation.**

OCS OIL AND GAS

The significance of the oil and gas deposits under the OCS is inevitably conjectural. It depends both upon the trend of consumption, which can be foreseen only roughly, and upon the size of the resource *in situ*, which cannot be estimated accurately without a great deal of seismic exploration and exploratory drilling.

The range of possibilities described in the CEQ Report is indicated in Table I. On the basis of the medium projection for consumption and the high estimate of OCS yield, the OCS could supply about one-fifth of domestic consumption of crude oil and natural gas in the year 2000. Given the more pessimistic yield estimate and the same consumption rate, the OCS would supply less than one-tenth of consumption in 2000. Although these ratios indicate the plausible order of magnitude, actual events may not conform to the suggested range. In appraising the significance of OCS contributions, it should be kept in mind that the oil and gas resources under the OCS will be nearing exhaustion by the end of the century.

TABLE I. CEQ Projections of Consumption and OCS Production of Petroleum and Natural Gas

		1985	2000
Oil (millions of barrels/day)			
consumption growth estimate[a]			
	medium	24	30
	low	14	12
OCS production estimate[b]			
	high	3.0	6.5
	low	1.0	2.5
Natural Gas (billions of cubic feet/day)			
consumption growth estimate[a]			
	medium	75	85
	low	75	60
OCS production estimate[b]			
	high	3.6	18.0
	low	1.2	8.0

[a] Adapted from the CEQ Report, Chapter 3. The energy content of a barrel of oil is about 5,800,000 Btu, and that of a cubic foot of natural gas is about 1020 Btu.

[b] CEQ Report, Chapter 7, total for all four regions.

The possible importance of OCS oil and gas can also be assessed by an economic analysis to determine whether a potential economic gain, exclusive of undetermined environmental and social costs, appears large enough to be capable of more than balancing these costs. Such an analysis also provides a basis for comparing the potential economic benefits of developing alternative energy sources instead of the oil and gas of the OCS.

The CEQ did not consider an economic analysis as part of its charge, so we have made one based on their data and on assumptions and methods described in Appendix II. We have assumed that during their 20 year lifetimes, the OCS fields will produce amounts of oil and gas that are intermediate between the high and low production cases used in the CEQ analysis. Using $8 per barrel for oil and $.75 per thousand cubic feet for gas, the gross lifetime revenues from the OCS fields amount to about $240 billion. From this amount the costs of exploration, development, and operation of the fields must be subtracted. A discount factor must also be applied because the recovery of the resource is spread over time and a postponement of its availability reduces its value. Taking into account the assumptions of Appendix II, we find that the contemplated development of this resource probably would have a net economic value of roughly $80 billion.

This would be a large return which would have the potential for offsetting the economic costs to other industries, such as fishing, recreation, and tourism, that might suffer as a result of the development. Although we have no means for judging the economic reductions that will be suffered due to OCS oil and gas operations, we believe that if precautions are taken, they may not be an appreciable portion of the estimated national economic benefits of producing the petroleum resources.

The enhancement of our national wealth from OCS development can also be significantly offset by non-monetary considerations. However, these social and environmental costs cannot necessarily be equated with purely economic values. Thus, even if large quantities of oil and gas can be developed with large economic benefit, it is not clear that this would be in the interests of the nation or of any particular region. This is especially true when it is not known whether a similar investment in some other potential source of energy would not yield the same, or a larger, net economic value at smaller social and environmental costs.

Analysis of the costs and benefits of employing petroleum as an energy resource as opposed to other uses is also necessary. Approximately 10 percent of the products of refined crude oil presently become such commodities as lubricants, greases, and asphalts, and feedstocks for petrochemical industries such as plastics, synthetic fibers, medicinals, pesticides, and fertilizers. In the event that substitutes for petroleum in the manufacture of such products are unavailable, the consumption of oil and gas for energy needs could conceivably deprive future generations.

It is essential that the net economic and social value of the full range of alternatives be considered before major policy decisions are made about the OCS. Such an analysis of alternatives was not performed in the CEQ Report. For each alternative the economic, social, and environmental drawbacks should be weighed against the anticipated national economic benefits of development. Furthermore, such analyses should be conducted for both national and regional resources. For example, an appraisal of the development of the Georges Bank for petroleum resources should consider its value as an international fishing grounds and the value of areas adjacent to it for recreational uses.

THE DISTRIBUTION OF COSTS AND BENEFITS

In evaluating the commercial exploitation of any national resource, the Committee suggests that it is important to consider the distribution of costs and benefits as well as their total values. The principle of such an appraisal should be that no one bears more of the cost than accrues to him as a benefit. A subsidiary consideration should be that benefits be widely and equitably distributed.

In the case of OCS oil and gas development, the environmental costs will be borne by all who derive pleasure or profit from the affected portions of the environment in its present state. Compensation should be given to those who can demonstrate the most severe prospective losses. Some degree of justice can be obtained for the rest of those affected by assuring that adequate payments are made into the national treasury in the form of lease bonuses and royalties.

NATIONAL RESERVES

Optimal timing of the exploitation of a reserve, once it is identified, has received inadequate consideration both by the CEQ and by the NAS committee. A reserve *in situ* is a stockpile, available for use in an emergency or as a hedge against future demand for feedstocks. An understanding of the costs of maintaining a reserve in the ground in varying stages of readiness is needed. In many instances, such a strategy may be preferable to above-ground storage of large reserves, a topic being discussed as a strategy to decrease the nation's vulnerability to foreign boycotts. We do not know which of the various underground reserves are best suited for stand-by roles of various kinds. It is possible that such a problem can only receive adequate scrutiny when exploration is divorced from production, a situation far from today's patterns of leasing.

PUBLIC POLICY

The Committee assumes as a principle that public policy should be established with maximum participation of the public and based on the availability of the most complete and accurate information obtainable. A corollary to this principle is that the most complete and accurate information should be available to the public. The facts on which policy is based should be disseminated as widely as possible and their implications carefully and clearly detailed. The recommendation of the CEQ that the public be encouraged to participate in the preparation and review of OCS impact statements, especially through state and local planning agencies, is most welcome.[2]

III. Resource and Environmental Assessment

A rational policy for the development of a natural resource requires knowledge of the amount and availability of the resource, the social and economic changes required by or attendant to the development, the enviromental constraints that will influence the technological operation, and the environmental changes that will result. This section is concerned with the inadequacies of current assessments, of both oil and gas resources and of the environment likely to be affected by their development.

OIL AND GAS RESOURCES

The amount and location of mineral resources in the United States are only partially known, because the required exploration has been conducted mostly by private interests. For economic reasons, private industry seeks the least expensive resources that are available worldwide and has little incentive to prove reserves to meet demand for more than a decade in the future. In particular, the federal government has not viewed the systematic determination of the availability of oil and gas resources as sufficiently critical to national goals to warrant the allocation of more than minimal resources for that purpose. As a consequence, assessments of the national treasure of oil and gas, including those reviewed in the CEQ Report, are little more than sophisticated guesses as to how much resource is available, even, to some extent, in explored areas. The Committee wishes to stress the uncertainty that currently prevails in these estimates of oil and gas resource availability.

However, the application of modern technology to oil and gas exploration can change this situation. One such technology is computer enhancement of "bright spots" that positively identify the presence of fluids with low sound velocities such as oil and gas.[3,4] Just as signal processing by computer can reduce a jumble of light and dark into a detailed picture of the surface of Mars, so too can the "bright spot" technology of seismic exploration mentioned in the CEQ Report now reveal in many places whether potential geological traps contain oil and/or gas. Drilling is not required in the application of this technology. While the information that can be acquired does not necessarily tell all that would be useful to know about undrilled fields, the knowledge to be gained from seismic exploration is now significantly greater than in the recent past. Furthermore, we believe that it is reasonable to expect that future improvements in this and other technologies will not only provide even more detailed information but also do so at reduced cost. Thus, we suggest that it is now possible and increasingly practical to survey our national treasure of oil and gas.

To accomplish this goal we therefore recommend that the federal government acquire and make public, together with supporting data and analysis, the best possible estimate of our OCS resources of oil and gas based on the new techniques, just as has traditionally been done for other energy sources such as coal and oil shale. This estimate can probably be obtained rapidly, and while the data processing is expensive, the cost is relatively low compared with the potential benefits. More accurate information regarding the resource potential will facilitate not only the formulation of national energy policy, but also the assessment of environmental impacts. Since the amount of resource *in situ* determines at least the maximum possible rate of production, it indicates the maximum expectable environmental impact as well. Furthermore, the resource is limited, and if we are to avoid the economic crises associated with the exhaustion of resources, we must plan their use with their ultimate depletion in mind. Such planning can only be undertaken if a reliable estimate of the total resource exists. For example, at the CEQ's high production estimate, the resources presently estimated to lie beneath the Atlantic and Gulf of Alaska OCS would be nearly exhausted by the year 2000.

Yet another uncertainty that should be clarified in order to understand the relative economic importance of developing new OCS resources is the degree to which the rate of production of oil and gas responds to market prices. During the course of the CEQ study, world prices for oil changed markedly. Few observers expect these prices ever to return to the level existing early in 1973. Higher prices stimulate increased activity from several sources: increased production from existing wells in established fields, drilling of new wells in established fields, and development of synthetic oil and gas from other mineral resources, all with accompanying environmental effects. Increasing prices may delay the need to develop completely new resources such as the Alaskan and Atlantic OCS.

THE ENVIRONMENT

The availability of more accurate information regarding resource potential has implications for the assessment of impacts as indicated above. The amount of impact will become greater as the magnitude of the development increases. Obviously, it is also necessary to assess the state of the environment likely to be affected, including the land, the air, and the water. Such an environmental assessment should be designed to allow for both qualitative and quantitative evaluations of impacts. Qualitative information often reflects social values but not the biological impact of an event on an ecosystem. Quantitative estimates should be made so that risks can be calculated and decisions based on these calculations as well as on social values when indicated.

From the CEQ study, which was based on existing data, and on the basis of its own understanding, the Committee agrees with the CEQ that present knowledge is inadequate for assessing thoroughly the likely physical and biological consequences of OCS development activities on the environments in question. Information is available in varying degrees of completeness. For example, the topography of coastal areas is well-known. However, weather conditions, sea state, and ocean currents are only partially known and do not provide an adequate base for assessment, design, or operation in every area. The functional dynamics of the ecological systems of estuaries, marshlands, and open waters and their interrelationships are complicated and differ in various geographical areas. In some areas the systems have not been adequately described. We, therefore, recommend that a vigorous effort be initiated to expand knowledge of the physical and biological environments and the ecological systems likely to be affected. In particular, we agree with the CEQ Report recommendation that potential impacts on commercial fisheries should be evaluated before development begins.[5]

A catalog of environmental parameters such as local air and water quality indices, meteorological conditions, acres of land in selected uses, and species of plants and animals is necessary, but not sufficient for an environmental assessment. Further understanding of the productivity and value of discrete ecosystems should be developed. Such an evaluation requires an understanding of the complex interrelationships between living plants and animals and the physical environment in an area large enough to be distinguishable as an ecological system. While it is frequently useful to classify ecosystems geographically into marshes, estuaries, offshore areas, and so forth, it is also important to recognize that within each classification there are both similarities and differences. For example, although intertidal areas consisting of marshlands and shallow estuaries generally are highly productive of renewable resources and serve as important nursery grounds for fisheries, not all of these areas consist of the same types of plants and animals or the same types of interrelationships. Thus, some may be more sensitive to environmental changes than others. It is important, therefore, that each ecosystem be assessed with respect to its uniqueness of character and its productivity, as well as its economic and social value.

Yet another parameter of each ecosystem should be assessed: its spatial extent. It is conceivable that some areas, although they represent only a small percentage of the area of the ocean or of the coastal zone, are sufficiently important biologically to preclude any serious development in their immediate vicinity. No such areas have been defined in the CEQ study, but they may yet be identified as understanding improves. Conversely, less productive and sensitive areas, where experience indicates that recovery from oil damage may be rapid, could be considered less vulnerable to intrusion and therefore more acceptable for development.

Economic evaluation of a particular discrete ecosystem should be directed toward analyzing its renewable resources (its fisheries in particular) and its relationship to other areas, e.g., as a nursery ground. For example, the Louisiana delta and marshlands are considered the controlling factors for fisheries production in the northern Gulf of Mexico. The Chesapeake Bay area has a similar relationship with the mid-Atlantic region and, without doubt, there are other such areas along every coastline that can be similarly identified as critically important to production of renewable resources.

Any stress that seriously alters the dynamics of an ecosystem should be avoided, since critical changes in its productivity may result. On the other hand, specific systems may be subject to varying degrees of natural stress, such as a decrease in the salinity of an estuarine system due to unusually heavy freshwater runoff. A system operating normally can overcome and repair temporary losses of its renewable resources in variable but reasonable periods of time. Therefore, the danger of environmental intrusion by man is not necessarily the temporary loss of populations but rather the loss of or permanent change in the dynamics of the system that supports its productivity. For this reason studies of the recovery of ecosystems from catastrophic damage resulting from natural stress are particularly critical. The Committee therefore recommends that, in order to improve the base of knowledge necessary for understanding and assessing the impacts of man's activities, data be developed to establish the natural ecosystem dynamics associated with production of renewable resources, with particular attention given to the effects of seasonal and occasional episodic changes in environmental parameters.

Ecological studies of an area that might be affected by OCS development should be conducted while plans are developing for exploration and engineering, so that the possible effects can be evaluated before significant impacts occur. The ecological data can thus help to evolve the system, rather than to impede ultimate development activities. In particular, the coastline and land-based services can be planned well in advance of construction to assure minimum adverse effects.

An essential element in a decision on OCS development is the definition of the physical environment: the combinations of weather, sea states, and ocean currents. These data, in greater detail, are also vital for design of structures and operating procedures, for risk evaluation, and for safe and economical operation.

The available physical data are more extensive for the Atlantic than for the Gulf of Alaska OCS. However, since these data are for the most part collected by shore stations or merchant ships, they are not optimal for design of OCS installations or for providing the warnings or modifications necessary for operations. In order to define the environment properly, carefully located buoys are needed to make observations extending over time. For example, information on ocean current profiles and their response to changing weather conditions may be needed to design towers or bottom-mounted storage or to develop operational strategies.

The MIT study of oil spill trajectories conducted for the CEQ calls attention to the fact that data relating to the transport of oil slicks by winds, waves, and ocean currents are inadequate.[6] Further, it emphasizes that model calculations based on present understanding of transport mechanisms are highly uncertain. Nevertheless, these calculations are used as the primary criteria for rank ordering of the OCS Atlantic coast development regions in the CEQ Report. We conclude that this reliance is not justified, and that more comprehensive studies are needed before adequate predictive models can be made. The major limiting weather and sea conditions should be described thoroughly through analysis of selected case studies. Experimental model calculations should be checked systematically against the results of field experiments.

It is clear that the available data do not recommend the development of OCS resources at the present time in the Gulf of Alaska. First, data on weather conditions, sea states, ocean currents, ecological system dynamics, fisheries resources, and the sensitivity of indigenous species to oil pollution are not well known. Second, operating conditions due to weather and sea states will be difficult, because storms are frequent, and their forecasts are less reliable. Third, the economic and social impacts of development on Alaskan coastal communities will be extreme. Finally, the frequency and severity of earthquakes and tsunamis in the area pose costly problems in engineering.

IV. Ecological and Economic Impacts

OCS oil and gas development, including the associated industrialization on land, will have ecological and economic impacts both at sea and ashore. These impacts may or may not be desirable or acceptable. Chronic and accidental discharges of oil and other pollutants and changes in the uses of land and water will cause both temporary and permanent changes in the environment. Local employment opportunities will be created and displaced with varying effects on the economic and social life of the affected communities. Although such impacts are interrelated, they are divided somewhat artificially in this section into ecological and economic categories.

ECOLOGICAL IMPACTS

Both permanent and temporary stresses can cause ecological impacts. Permanent stresses result from development of harbors and construction facilities, placement of platforms and pipelines, dredging and filling operations, alteration of drainage patterns, and construction of refining and petrochemical complexes. Chronic pollution by the operational discharge of brines from active fields may also be considered to be permanent, since these discharges—which also contain some oil—continue and actually increase with the age of the field. Permanent effects may be further subdivided into direct, indirect, and associated problems. Direct effects involve the permanent loss of land or water bottoms to structures, dredging operations, and spoil placement. Indirect effects, which cause the greatest damage to ecosystem dynamics, are broader in scope, involving changes in water circulation, salinity, turbidity, and chronic pollution. Associated effects involve a multitude of changes in land use, air and water pollution, and other problems resulting from such secondary developments as construction of industrial complexes and housing, and shifts of populations to or within the coastal zone.

Temporary ecological impacts are generally associated with accidents such as well blowouts, loss of drilling muds, and oil spills. These occurrences can be costly and destructive and reduce productivity of the impacted area. After a variable amount of time has elapsed, the affected ecosystem generally will recover to a point where the normal biota and ecosystem activity are restored.

The significance of such impacts may be measured by their spatial extent and the length of time required for recovery. The recovery time depends not only on the species present in the area and their interdependencies, but also on the persistence of the pollutant in the environment. As indicated in the CEQ Report, the persistence of oil in the marine environment is still poorly understood.[7] Conflicting observations on the persistence of oil and its long-term effects on the local ecosystem abound in the published literature. Evidence exists for rapid degradation and dispersal of oil by natural processes. On the other hand, there is also evidence of continuing impacts due, for example, to periodic releases of hydrocarbons that have been incorporated into sediments, where they can persist unchanged for long periods of time. We suggest that the questions surrounding the persistence of oil in the marine environment should be resolved through careful and intensive investigation before irreversible damage is inflicted on biologically and economically sensitive areas.

Having determined the nature of the temporary impacts, it is important to predict the frequency with which they occur. The CEQ study has revealed interesting and useful statistics on the probabilities of accidents.[8] These statistics should lead to a further analysis of the causes of failures, both physical and operational, so that technology can be developed and implemented to reduce their recurrence.

Accidental spills should also be analyzed for the probability of reaching an ecologically sensitive area.

This probability depends upon the location of the source, the type and amount of pollution, the location of the ecosystem affected, and the season of occurrence. The size of the spill and the extent of the area affected would be important in evaluating the impact on the function or productivity of the area. The CEQ study has addressed these problems for accidental spills at possible production sites offshore and for selected local areas based on the work performed by MIT.[9]

The probability of localized impacts based upon computed drifts or trajectories of oil slicks using historical wind and weather data could be helpful in evaluating the relative hazards of different drilling sites or locations for shore–based pipeline terminals, transfer facilities, or refineries. However, as noted in Section III, the data on which the study is based are inadequate and the model uncertain. The probabilities in the CEQ Report are based on a large number of simulated trajectories using hypothesized mean currents and stochastic winds. The mathematical simulations were checked against drift bottle data that may or may not have meaning for the tracking of oil spills. Because the mathematical and physical models of the transport mechanisms are themselves uncertain, we do not have confidence in present capability to predict the probability of localized impact due to the movement of oil spills.

We wish to emphasize that for a particular spill at a given time predictions of the probability of that spill reaching a particular location may be misleading. Since spills are not expected to occur frequently, the degree of risk will be determined by the actual weather and sea conditions at the time of the accident and for a period of time following it.

The toxicity of crude oil and its fractions is also little known and poorly understood.[10] Most of the literature on toxicity has evolved from laboratory experiments or from heavy spills into small areas. An evaluation of the toxicity problem should account for the amount of oil spilled, the proportion of the toxic fraction, the total volume of water polluted and its rate of replacement, and the surface area involved. This type of analysis over many variations of the environmental parameters does not exist, as the CEQ study implies.

A thorough evaluation of an oil spill impact on an ecosystem, its productivity, and economic structure, requires estimation of the size of the spill, the probability of oil reaching the area, the physical and biological effects of the oil, its persistence in the environment, and the resilience of the ecosystem to the intrusion. The resilience of an ecosystem is determined by its internal dynamics. As we indicated in Section III, some systems, for example, estuaries and deltas, have inherent dynamic characteristics that permit them to withstand highly variable and seasonal changes in their natural environmental parameters. In specific cases these natural fluctuations can be so great that they overshadow any effect from either chronic or accidental spills thus far observed. Many communities and species are transient; their appearance and disappearance by season or by some other short interval of time may obscure the impact of a localized and temporary stress from oil. Even assuming that most of the living organisms were killed within a local area, the total productivity of the ecosystem might still fall within the measurable limits of annual variations in production. Thus, only cumulative losses in acreage or changes in the composition of the biota would give evidence for measurable permanent damage.

It should not be inferred, however, that recovery from unnatural or man–made stresses, whether chronic or temporary, can always proceed without measurable long–term effects. The response of a particular system to an unnatural stress may differ from that due to natural variations, especially since the existing ecosystem has developed as a result of tolerance to the usual range of natural phenomena. Clearly, the response of a specific ecosystem to man–made changes will depend critically upon the system, its dynamics, and the nature of the alteration.

The impacts of oil pollution on ecosystems in different habitats will differ. Oil spilled near stable shores with narrow intertidal zones is likely to be washed away by wave action more rapidly than oil spilled in estuaries and marshlands with wide, shallow intertidal zones. In these latter areas, pollution is more likely to be trapped and incorporated into sediments where it can persist for long periods. The finer sediments, such as silts and clays, will retain oil for longer periods than will clean sandy sediments. As the CEQ Report concludes, the economic impact of oil pollution in estuaries and marshlands is also likely to be more significant because these areas generally serve as feeding and nursery grounds for many important commercial species of fish and shellfish.[11]

The CEQ study has concentrated primarily on the fates and effects of temporary oil spills from offshore locations and secondarily on the impacts of chronic discharges. The Committee concludes that insufficient attention has been given to permanent direct and indirect effects and to the effects associated with onshore development. In particular, the environmental effects in the coastal zone due to economic activities accompanying OCS development, such as changing land use patterns and population centers, ought to be examined in detail.

One type of permanent impact treated in the CEQ Report results from the landfall of pipelines.[12] Dredging, filling, and damming in unstable estuarine and deltaic regions can alter drainage patterns, leading to loss of land and to changes in the physical and chemical environment with resultant ecosystem changes. Much less damage may occur, however, if pipelines come ashore at stable shores.

While all of the necessary information regarding the impact of oil on the marine environment is not available, definitive conclusions can be reached for some effects. For example, the evidence on the effects of oil on birds is clear. Toxic results are known where refined oils have been spilled in confined areas. The distribution of tar balls in the open sea is well known, as is their presence on beaches. In contrast, clear damage by sublethal chronic contamination in the Gulf of Mexico has not been demonstrated. Ambiguities arise because most studies have been incomplete, inadequate, and transitory, and the effects of spills in the open seas have rarely been studied.

REGIONAL ECONOMIC IMPACTS

Oil and gas development on the OCS will alter local and regional economics as well as the ecosystems in which they take place. In recognition of this fact, the CEQ has correctly focused on the necessity of managing development in order to avoid permanent degradation of the environment and unnecessary disruption of traditional local values and life styles. Further, the Report attempts to provide a methodology for gathering the information needed by state and local officials, who must make plans in the face of difficult and complex decisions on growth and land use. To assess both the favorable and unfavorable economic impacts and the associated environmental impacts, the Report has addressed, identified, and quantified impacts on employment, value of production, and total population in the local and regional economies. The study further translates these data into estimates of land requirements, air and water pollution loadings, and a selected list of impacts on the social infrastructure.[13]

The Committee agrees with the concerns of the CEQ and is encouraged by its attempt to quantify the likely onshore impacts in order to provide information that we consider to be vital both to decision-making and to planning. Because the methodology for this type of study is of critical importance to its usefulness, we wish to call attention to what we consider to be deficiencies and omissions in the present study as prepared for the CEQ.[14]

The obvious first step in this type of analysis is the definition of the appropriate geographic dimensions of the impacts of OCS development. The study has separated potential impacts simply into offshore and onshore categories. Offshore impacts are concerned primarily with the fates and effects of oil pollution originating at or near potential development sites. Onshore impacts include the effects of employment and production in specific oil and gas receiving and processing locales and regions and the attendant air and water pollution loads. Although the selection of the specific study sites could be questioned, we recognize that for the present purposes the analysis is intended only to illustrate a technique.

We are concerned that the manner in which the impact dimensions have been geographically segregated, with selected effects considered under each division, does not facilitate a complete understanding of the total development process. By omitting from treatment such important activities as those that take place somewhere other than at offshore production and onshore industrial sites, the CEQ study has neglected an important dimension. This difficulty applies to the analysis of environmental as well as economic impacts. The discussion of the Puget Sound area, for example, omits analysis of the consequences of increased tanker traffic in the inside waters of the Sound—waters that are subject to treacherous tidal currents, dense fogs, and high winds. Collisions or groundings within the narrow passages of the Sound could cause extensive ecological and economic damage throughout the entire region.

Commercial fishing, to cite a further example, is an economic activity that takes place both offshore and onshore. The geographic classification used not only eliminates from consideration the offshore activities of fishing, but as a consequence does not register the onshore impacts on fish processing and support activities due to possible reductions of offshore fisheries production.

A suitable methodology, therefore, must begin with a regional definition that embraces the entire development process in an area large enough to be distinguishable as a complete system. Within this region a hierarchy of inter-related areas should be defined in accordance with their economic characteristics. For example, we suggest that in the case of the Gulf of Alaska the large region within which OCS development would operate is Southcentral Alaska, including the offshore continental shelf areas (this is the district used for administrative and planning purposes by state agencies). Analytical units within this region would be the Anchorage area (headquarters and support area for all Alaska petroleum development), the Cook Inlet basin (presently developed petroleum, gas, and petrochemical industries), and the Gulf coastal and outer continental shelf area (the area under consideration in this study for future development).

A second step in analyzing impacts is to devise simple but appropriate models of each regional and local economy. These models should reveal the specific nature of each economy in order to identify and measure impacts properly. The present study uses the same five sector models for all areas and the same multipliers in calculating induced employment, production, and total population from the oil and gas development impacts.[15] The sectors are too limited in number and scope to describe a complete economy. Furthermore, the data sources appear to be civilian, non-agricultural wage and salary employment and payroll series which exclude or understate defense, commercial fisheries and agricultural activities. The application of this uniform and incomplete model to every economy and the use of limited economic data obscure the variations in local economic structures and the unique functioning of each, and distort the projection of development impacts.

Projections of each base case economic development must be tailored to specific regional structure, growth behavior, and anticipated future conditions; thus such forecasts in general will be more complicated than simple linear projections. A study of actual case histories of regions that have experienced offshore developments would provide useful guides. Examples of these are the Gulf of Mexico development and its impacts on the coasts of Louisiana and Texas, the more recent development of offshore oil and gas in the upper Cook Inlet and its economic and social impact upon the Kenai Peninsula Borough and the City of Kenai, and the North Sea development and its impacts on the east coast of Scotland.

In addition to what we view as deficiencies in the design and methodology of this study of economic impacts, we find several specific aspects that are either omitted or inadequately treated in the Report. For example, impacts are a function not only of the nature and magnitude of the development, but also of the rate of development. When such programs are undertaken on a crash basis, the local and regional economies may be subject to the economic and social ills of boom and bust. Slower, controlled development rates over longer periods would minimize these distortions. Ultimately, an economic activity based on a nonrenewable resource must confront the predictable end of its existence. The social and economic costs of adjustment to this outcome must also be considered in assessing regional economic impacts.

Alteration of land use patterns can have both environmental and economic impacts. The CEQ study has classified present and future land uses in selected locations to identify the amount and general location of land that will be available to development.[16] All land has a use, either for man, for nature, or for both. The development of land changes its use from one purpose to another, and such changes have social, economic, and environmental consequences. For instance, the disturbance of a marshland ecosystem by dredging and filling operations may have indirect economic costs if marine resource nurseries are lost. Loss of agricultural lands represents a direct economic cost, especially if those lands are particularly suited to specialty crops because of unique conditions associated with their proximity to the ocean. Examples of such crops are the cranberries of the bogs of Massachusetts and New Jersey and the artichoke fields of the central coast of California. Social costs of changes in land use can result from the loss of open space, beach-land, and recreational facilities, all of which have associated economic costs.

An additional consideration in assessing economic-ecological impacts of OCS gas and oil development is the transportability of crude oil and natural gas. Because oil and gas can be transported at low cost by pipeline, tanker, or barge, alternatives for refinery locations exist at different economic and environmental costs. In the Gulf of Mexico, transportation costs have amounted to about six percent of the cost of production per barrel.[17] Thus, as the CEQ Report suggests, both the social benefits that may be derived from siting and the costs of various refinery locations should be taken into account in planning for development.[18]

There are potential conflicts and confluences of interest between several other ocean-based technologies all in comparable early stages of planning at the present time. For the most part, the studies of these technologies are proceeding in isolation from one another. Particularly, these are offshore power plants, deep-water ports, and offshore drilling. Potential mutual enhancement clearly exists between deep-water ports and offshore drilling. The interactions of nuclear power plants with the other two are less clear, but a major design consideration for offshore nuclear power plants is the need to protect them from damage in collisions with ocean vessels; as the largest vessels afloat are oil tankers, there is evidently a potential desirability for zoning the coastal regions to prevent large tankers from coming near offshore power plants. There are doubtless other positive and negative interactions that deserve careful attention, again as much to uncover otherwise missed opportunities as to discover unforeseen obstacles to development.

V. Technology and Risk Evaluation

The Committee concludes that improvements in OCS technology can and should be developed and implemented to minimize damage to the environment resulting from offshore operations, the transportation of oil and gas, onshore siting and construction, and petrochemical operations. The CEQ Report[19] has reviewed the state of the technology and OCS lease management and operating procedures, relying primarily on previously published studies.[20-24] The Committee concurs with the CEQ in recommending further developments of OCS technology and better systems design, operating procedures, regulation, and management.[25] Some additional comments and discussion are given in this section.

To ensure the existence of adequate technology for environmental protection and safety, appropriate governmental agencies should be given responsiblity for conducting and/or sponsoring research and development in the areas of engineering relevant to these aspects of OCS operations. In the absence of incentives, industry should not be expected to provide sufficient effort in this area.

We recommend the adoption of two principles applicable to the assessment of technology and risks as described in this section. First, the costs of all operations for safety and environmental control for OCS operations should be included in the costs of the crude oil and gas produced. Second, the public rather than the operators should determine the balance between the levels of risk assumed and benefits obtained in areas of public interest.

ENVIRONMENTAL PROTECTION

An effective program of environmental control of both accidental spills and chronic discharges should be a prerequisite for new OCS oil and gas development along the Atlantic coast and in the Gulf of Alaska. Much of the technology exists, but improvements can and should be developed as necessary. Equally important are better systems designs (taking human factors into account), improved regulation and enforcement, better trained operating personnel, and a firm commitment to environmental protection by OCS operators.

COSTS

The CEQ Report does not describe incremental costs of various applications of current technology to environmental protection. We conclude that such data would be useful and hope that such a study will be initiated. We recognize that in some instances the costs of safe operation and environmental controls may increase the cost of extraction beyond the level at which operations are economically attractive. In such a case, resources should be developed elsewhere under circumstances where total costs–with environmental costs properly taken into account–are less. Importantly, the fact that environmental controls in such a case are costly should not be used as grounds for reducing the level of control, but rather should indicate that the development of the resource should be deferred to a time when the costs of environmental control are reduced through technological advances or when the value of the resource increases.

RISKS

Accidental spills result either from the failure of equipment or from human errors and deficiencies in operating procedures. Almost by definition some risk of an accident always exists, but we believe that improved technology and adequate managerial and operating procedures can reduce these risks. Because the costs of such protection will be borne by the public, the public should evaluate the levels of tolerable risk for which it wishes to assume the burden. The perception of risk by the operators ordinarily does not account for environmental and social costs and will not do so in the absence of economic incentives or regulations designed for that purpose. We recommend that appropriate incentives be provided to the operators as inducements to maintain firm commitments to the levels of environmental protection and safety deemed acceptable by the public.

As recommended by the CEQ, specific design and performance criteria for structures, tankers, pipelines, and other equipment should be established by appropriate government agencies.[26] These criteria should specify for each leasing site the intensities of extreme natural hazards (winds, waves, currents, ice, earthquakes, and tsunamis) that OCS structures and equipment must withstand without failure. An intensive effort at collecting oceanographic and meteorological data for specific leasing sites will be necessary before these design standards can be rationally established.

The coastal and offshore structures, including harbors and waterways, that a developer proposes to build and operate should be closely reviewed by a regulatory agency to ensure compliance with established design criteria. Furthermore, the developer should make available to the agency complete information on structural and foundation analyses and the results of all special structural and hydraulic model tests. The regulatory staff should include engineers with appropriate specialized qualifications for complete review of such structures.

For tankers and ships, particular attention should be given to measures for reducing chances of collisions and groundings, such as improving navigational aids and shipping lanes—especially in harbor approaches—and installing adequate collision warning devices on both ships and platforms.

CHRONIC DISCHARGES

Chronic discharges of oil may far exceed the amounts from accidental spills during the life of an offshore oil field, and may be more significant environmentally. Systematic evaluation of the sources of chronic discharges to the environment is necessary to devise the best corrective measures.

A major source of such pollution is the ocean dumping of well brines, which under current controls may contain as much as 100 parts per million (ppm) of oil with an average of less than 50 ppm. Separators with adequate carrying capacity should be required to satisfy specific performance criteria for removing the oil from these brines. It may be desirable to limit the gross emission rates of oil that can be tolerated from any given structure or over any given area, rather than specifying the percentage of oil in the discharged brine. The brine should also be studied for its impacts on the environment, because of its high content of dissolved solids, including heavy metals.

As indicated by the CEQ, tanker and barge operations are also sources of chronic pollution near shore and at sea, and should be controlled.[27]

VI. Institutional and Public Policy Issues

Development of oil and gas resources from the OCS will require important changes in local, state, and federal institutional policies and relationships. In fulfillment of its mandate, the CEQ has addressed some of these needs in its Report, particularly those most directly related to environmental protection.[28] In this section, we address not only these, but also other issues that are important to public and federal agency formulation of OCS resource policy.

LEASING FEDERAL LANDS

As noted in Section III, knowledge of the OCS resource potential and its attendant environmental values is an essential prerequisite to sound policies for the exploitation of OCS oil and gas resources. Several options exist for improving federal resource information policy and for permitting full public disclosure: federal agencies might obtain basic resource information (a) by their own exploration and interpretation prior to the sale of leases, (b) by requiring a quasi-governmental or public corporation to do so, or (c) by permitting competitive bidding for data-gathering contracts. Knowledge obtained in any of these ways would allow the federal government to maintain maximum planning capabilities for OCS energy resource development. A federal agency could, for example, compare the economic worth of a potential leasing area with the environmental degradation and risks that a sale would cause. Because the concept of private proprietary resource information would be eliminated, public availability of such data would be both possible and desirable. Another option, with more far-reaching policy implications, is establishment of a non-profit, federally-chartered corporation to engage in all aspects of oil and gas exploration, development, production, refinement and distribution in cooperation with and in competition with private industry.[29] Whatever the instrument, disclosure of resource data might encourage widespread and aggressive bidding among prospective lessees.

We believe that a significant opportunity now exists for forming an institutional structure based on public knowledge of oil and gas resources. In order to achieve this goal, careful study should be given to these and other policy options prior to the sale of leases in new OCS areas.

Leases to exploit public resources should also be altered to account for the public availability of resource information. It may be advisable, for example, to substitute royalty or some other form of lease bidding for the present bonus-bid system. Royalty rate bidding might be appropriate at rates consistent with ever-increasing oil and gas prices.

Before any lease is awarded, other factors must also be assessed by federal agencies, such as the past record of the operator in achieving and surpassing minimum standards for production and environmental protection. The federal government should seek vigorously to establish the principle that OCS lessees have a license to develop public resources for the public benefit and so must be held accountable to strict standards in the public interest.

The Committee suggests that royalties and/or bonuses, whichever are applicable, should be distributed as benefits to those by whom the costs are borne. Because many of the costs of environmental protection and degradation are incurred locally, some portion of the dollar royalty benefits of OCS development should be returned by the federal government to these locales to offset coastal planning, regulatory, and other associated costs.

COASTAL ZONE MANAGEMENT

Development of OCS oil and gas is clearly a national concern, but its implementation must be carried out in ways that conform with state regulations and coastal zone plans. Because the impacts of OCS development on the coastal zone can be minimized by careful planning, we conclude that it is imperative that an open, effective institutional planning structure be created and adequately funded that will utilize the capabilities of federal, state, and local governments. Decisions within that process on land use planning and regulation should reflect national as well as regional environmental, economic, and energy interests. For each development, the affected state should retain the right to impose its own special conditions for protecting waters within its jurisdication and for controlling the impacts of land-based developments of ancillary services ashore. Federal leases should require that OCS operators comply with these standards.

As described in the CEQ Report, major environmental and social problems and dislocations will be caused by OCS operations once leasing has occurred.[30] The Scottish experience with North Sea development reveals that the fabrication of platforms and the establishment of onshore service and terminal facilities demand the most careful and sophisticated planning and controls long before any oil and gas are produced. Without such planning, local and state governments will be subject to highly unpredictable private economic determinations of the locations for onshore facilities. We conclude that the Coastal Zone Management Act—the only existing mechanism for comprehensive national coastal protection—should be strengthened and fully funded to encourage the development of coastal zone management plans and regulations.

Whatever management policy is adopted to provide equitable treatment of national and local needs, we believe that no OCS leasing should occur until after the development of adequate coastal zone plans.

REGULATION AND SURVEILLANCE OF OCS OPERATIONS

Staffing and funding for resource assessment and enforcement should be commensurate with the increased magnitude of the OCS program. The extension of OCS oil and gas activities to new areas will strain the existing capacity of federal agencies to assess new tracts for resource potential and environmental problems and to regulate OCS operations once begun.[31] Substantial increases in funding for the Bureau of Land Management, the U.S. Geological Survey, and the U.S. Coast Guard may be required to match projected plans to lease 10 million acres in the OCS in 1975—a tenfold increase over leasing in 1973.

We endorse the recommendations of the CEQ for a regular, frequent, and rigorous OCS enforcement system, for a new system of punitive shut-ins and administrative fines, for formal inspection training programs, and for citizen suit provisions that will permit interested persons to seek judicial remedies for OCS regulations and permits.[32] In addition, we recommend that the federal government adopt strict standards regarding liability of OCS lessees for pollution damage on and offshore to both private and public parties. Such highly certain liability can be assumed by OCS operators as the cost of doing business and has already been recognized as legal and appropriate for coastal protection by state and federal courts and agencies.

A basic policy question related to OCS development and enforcement administration is whether these functions should reside in separate federal agencies. We agree with the analysis of the University of Oklahoma, which suggests separating resource development and regulation within the federal government, rather than integrating them under the responsibility of a single agency.[33] Such separation could promote the public availability of information that otherwise might be hidden behind bureaucratic barriers.

ENVIRONMENTAL IMPACT STATEMENTS

The most thorough and rigorous federal environmental assessment of new OCS programs is based on the environmental impact statement process required by the National Environmental Policy Act (NEPA) of 1969. This tool for management planning and decision making has not been used to its full potential by federal agencies. It can prove particularly useful for OCS programs at various stages: when a new leasing program and schedule are proposed, when a particular region is subsequently proposed, and finally when a particular lease sale is contemplated. A new impact statement process should begin as each stage is being planned.

To assess environmental impacts on both the programmatic and regional statements, baseline data on the environment itself must be gathered. Our critique and the CEQ Report have outlined some kinds of data and analytical methods required for adequate assessment. To make effective use of the impact statement process, it will be necessary to obtain extensive new data and to make more rigorous environmental analyses for future impact statements.

As the CEQ Report suggests, the use of impact statements as guides to decision making should be promoted through improved substantive contributions from other expert federal, state, and local agencies and by the interested public.[34] New data, new analyses on cumulative effects, and new public attitudes require constant evolution of impact statements. To facilitate that useful evolution we suggest that federal agencies develop specific guidelines for these statements and take positive steps to encourage meaningful public and governmental participation in their writing and review.

INTERNATIONAL ISSUES

Under the 1958 Geneva Convention on the Continental Shelf, governments of coastal states are permitted to explore and exploit the natural resources of their continental shelves, arbitrarily defined as the water bottoms under less than 200 meters of water, and beyond to depths limited by technology. Until recently, the lack of technological and economic feasibility did not encourage exploitation beyond a depth of 200 meters, but this situation has changed with recent leasing at greater depths in the Gulf of Mexico. Thus, development of the OCS beyond the 200 meter depth in the Atlantic and Gulf of Alaska may also be contemplated. Unilateral extension of development below 200 meters in these waters could jeopardize international treaties, conferences and negotiations regarding pollution, fisheries, and the law of the sea. A moratorium on further leasing on deep extensions of the OCS would be advisable until the international issues are resolved.

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Appendix 1.
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Appendix 2. An Analysis of the Economic Value of OCS Oil and Gas

The calculations below are made for the purpose of illustrating the kind of analysis from which estimates of the economics value of OCS oil and gas can be derived. The results of the analysis presented might be widely different if other parameters are used or if other amounts of recoverable oil and gas are assumed.

To estimate the gross economic value of the OCS oil and gas development under study by the CEQ, we have assumed that, during their 20 year lifetimes, the OCS fields will produce some 24 billion barrels of oil and 73 trillion cubic feet of natural gas. These figures are intermediate values within the range of possibilities forecast in the CEQ Report. Assuming reasonable values of $8 per barrel of crude and $.75 per thousand cubic feet of gas, the gross lifetime revenue of this development is about $240 billion.

The most pertinent data available for making an estimate of the costs of development and operation of OCS fields, and resulting flows of oil and gas, are those prepared by MIT for the CEQ study.[a] The field of medium size analyzed has a lifetime yield of 388 million barrels of crude. The entire OCS development can be considered as a sequence of about 60 of these fields. The life history of this typical field is two years of construction and development, followed by about seven years of operation during which additional wells are produced. Oil and gas from a given well appear at an exponentially declining rate. Given the prices noted above and a 6 percent real rate of discount, the present value of the oil and gas revenues as of the time that construction begins is about $2,600 million. The corresponding present cost of construction and operation is $240 million; the net present value of the resource is thus about $2.4 billion.

The value of the entire contemplated OCS development can be appraised roughly by extrapolating from the data given above. Information supplied to the CEQ indicates that the fields will be brought in gradually, with construction of the first beginning in 1978, twelve fields in operation in 1985, and full development of twenty-five fields in 2000.[b] Assuming that the number of fields grows linearly during the twenty-year operating lifetime, the present value of revenues as of 1978 is about $87 billion, and that of development and operating costs $8 billion, making the net economic value of the resource about $80 billion. From this might be subtracted the costs of exploration, which although large in absolute magnitude, are small in comparison to the estimated net economic value.

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[a] Massachusetts Institute of Technology. 1974. Offshore economic model. Draft report to the Executive Office of the President, Council on Environmental Quality. 35 pp.

[b] Resource Planning Associates and David M. Dornbusch and Co., 1973. Potential onshore effects of oil and gas production on the Atlantic and Gulf of Alaska outer continental shelf, Vol. 1, Chapter 1. Report to the Executive Office of the President, Council on Environmental Quality, December 1973.

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